CIVIL ENGINEERING

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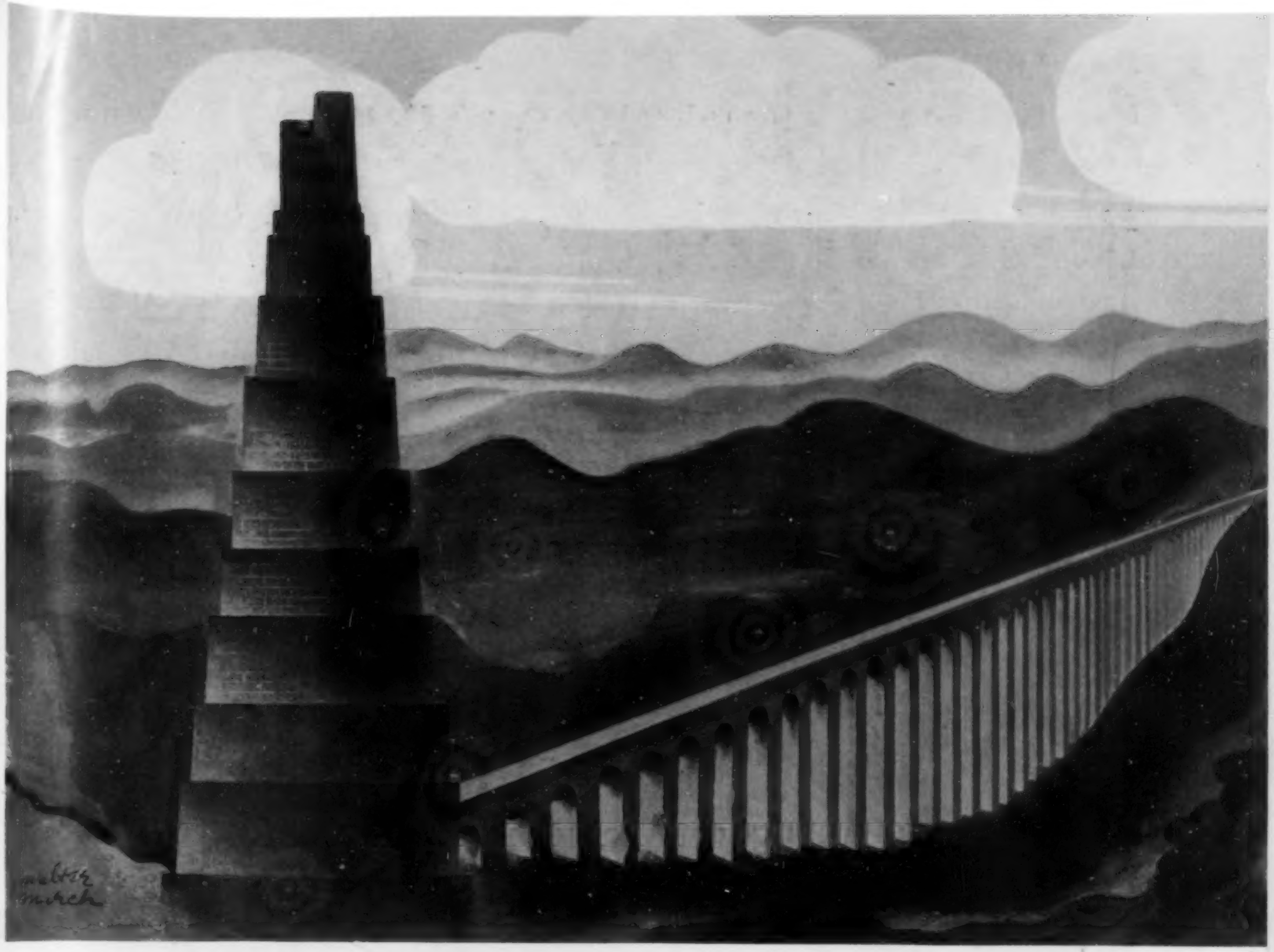
THE SIEGE OF CAIRO, ILL., FEBRUARY 1937
The Sea Wall, with Its Temporarily Heightened Crest, Holds Back the Record-Breaking Ohio Flood

Volume 7 — AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852 — *Number 5*

MAY 1937



From an Original Painting by Walter Murch, New York, N. Y.

Ancient Engineering Design Is Not Without A Modernistic Touch

THIS striking example of construction in old Mexico, located at Los Remedios, was once an important part of the water supply system leading to Mexico City, twenty miles away. The water tower is built of stone and is said to have been designed for emergency use as a fortress. The artist has well caught the harmony of these structures with their unusual surroundings.

Among Our Writers

Daniel W. Mead, President of the Society for 1936, is well qualified by his 52 years of experience in engineering to give some worth-while advice to the younger men who are about to begin their professional life by graduation from technical schools during the current month.

R. N. Bergendoff has had 16 years of experience in bridge design, chiefly with the firm of Harrington, Howard and Ash, and it successor, Ash-Howard-Needles and Tammen. He was in charge of design of the Neches River Bridge at Port Arthur, Tex., among other structures.

S. J. Horn graduated from the U. S. Military Academy at West Point in 1925 and later received a C.E. degree from Cornell University. His experience in the U. S. Engineer Corps has included 4 years as instructor at West Point. Since July 1936 he has been assistant to the U. S. District Engineer at Louisville, Ky.

Warren J. Mead taught geology at the University of Wisconsin prior to 1934, when he became professor of geology and head of the department at Massachusetts Institute of Technology. For the past 30 years he has been consultant on many foundation and dam-site problems in this country and elsewhere, including among others those at Boulder Dam and Madden Dam.

Paul A. Smith has been with the U. S. Coast and Geodetic Survey since 1924, and now is assigned to the Division of Hydrography and Topography of that bureau in Washington, D.C. His varied experience includes hydrographic and geodetic surveys in many parts of the United States, Alaska, and the Philippine Islands.

W. H. Boyer, who has been in the employ of the New Jersey Zinc Company for about 30 years, is now chief accountant at that company's Palmerton, Pa., plant. A native of this part of the country, he is greatly interested in early structures, and in historical developments.

Irving A. Jelly has been employed for over 20 years by the New Jersey Zinc Company. He is now an engineering draftsman at Palmerton, Pa. Mr. Jelly is much interested in art, particularly in etching Pennsylvania furnaces, bridges, and mills, such as those shown in this issue.

W. S. Housel has taught civil engineering at the University of Michigan since 1924, becoming associate professor in 1936. For a number of years he has been engaged in research in soil mechanics, combining academic activity with consulting practice. The address abstracted herein was delivered in Ann Arbor, Mich., in February 1936.

Gilbert F. White holds bachelor's and master's degrees in geography from the University of Chicago, 1932 and 1934, respectively. He served as associate research technician for the Water Planning Committee of the National Resources Board in 1934 and 1935. He is now secretary of the Water Resources Committee.

Editor's Note: In "Among Our Writers" for March 1937, the statement was made that F. H. Fowler "has had over 30 years of experience in sanitary engineering work," whereas Mr. Fowler's achievements lie rather in the field of irrigation, power, and flood-control work. In the April number, through a typographical error, the date of A. Warren Simonds' first connection with the U. S. Bureau of Reclamation was given as 1937 instead of 1927.

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Something to Think About

A Series of Reflective Comments Sponsored by the Committee on Publications

Experience Counsels Youth

Society President Gives Some Sage Advice to Young Engineers—Extracts from Talk Before Student Chapter Conference at Society's Fall Meeting in Pittsburgh, October 15, 1937

By Daniel W. Mead

Past-President and Honorary Member, American Society of Civil Engineers; Consulting Engineer, Madison, Wis.

We older men whose professional work is almost over are greatly interested in you younger men who are now being trained to enter the engineering profession, for we know that you are the ones who are going to take our places and carry the engineering banner to still higher attainments. In the past we stood on the shoulders of those who went before us; in the future you will stand on our shoulders, and your duties and responsibilities will be even greater than have been ours. The next fifty years of progress should carry the nation through developments and improvements which even our imaginations fail to visualize at the present time.

The accumulated knowledge and experience of the past is a heritage which you must utilize with the highest intelligence and to the best advantage for the future of civilization and of our profession.

Cultivate Wide Interest.—To every student in our engineering colleges I would emphasize the fact that commencement is just what that name implies. It is not only the commencement of professional life but it is the real commencement of professional study. It should include also the commencement of a wider study not only of engineering subjects but of additional subjects which your limited college life has not permitted you to undertake. Your future success depends on a broad foundation which will permit you to obtain a correct perspective of the proper place of your work in promoting the welfare of the world.

In college, you are working somewhat blindly towards certain desirable ends. In most cases it is more than likely that the end you anticipate will not be reached; but if you are earnest and if you are a worker, the ends that you finally do attain will probably be even more satisfactory than those you now think you desire. For the greatest success in whatever you may be called upon to do, be sure that you do the best that you possibly can with each and every assignment, and success will surely follow.

Sometimes students in college complain that they are obliged to study subjects in which they are not interested, and that they would much prefer the pursuit of some other subject. That is a good foretaste of real life. Something comes up that you must do, and you don't want to do it. The question should be "Can you do it, will you do it?" You can excel in it if you will. In fifty odd years I have never had a client ask if I would "like" to do a job. They say, "We want you to look into this matter for us." And they know that it is my business to be interested and to see that their problem, whatever it is, becomes for the time my great interest in life, and that it is answered to the best of my ability. In this way only can an engineer accomplish the best of which he is capable. The successful accomplishment of a required task, even though that task be distasteful, is a splendid training for a successful professional future.

Honesty the Only Policy.—I fear that favorable advice on public and private work sometimes comes from the desire of the engineer to get himself a future job; not that he is intentionally dishonest and deliberately misleads his clients, but he is human—he knows that if he makes a favorable report on a project, it will mean that probably he will be called upon to design and construct the works. With this perhaps unrecognized desire, difficulties seem insignificant and contingencies remote. Chances are sometimes taken with other people's ventures which would not be taken were the project one's own.

An old banker friend of mine, whom fortunately I met very early in my professional career, had the right attitude. He used to say, "I wish you to look over this proposition for me and tell me whether or not, if you had the money, you would be willing to

invest in it." That one contact has furnished a guiding principle for all my later actions. Since that time it has formed my standard for every report. This is the only fair and safe criterion. You can never honestly say, "I would not be willing to invest in this project myself but I think you had better do so."

It is an old saying, and a true one too, that honesty is the best policy. But if there is anything I dislike to see it is a man who is honest on account of policy. We must be innately honest. It is sometimes a hard thing to give the straightforward, truthful advice to which your client is entitled, when such advice seems to be adverse to your personal interest. For success, you must eliminate your own interest, and detach yourself from your apparent future as it relates to every proposition on which you are called upon to report. If you do this, there is no question but that you are on the true road to the greatest success.

We are living in a disturbing age. Ideals seem to have deteriorated. Nevertheless, true success still demands the highest honor and integrity on the part of the professional man. If this nation is ever going to reach its proper goal, we must have men of high ideals and unquestioned integrity at the head of all our important activities. Where should these high ideals be found if not in our great profession?

There is a little verse—I do not recall the words—but the general idea is that frequently you should stand aside and watch yourself go by. Think what you are doing, and whether you have done and are doing the things that you should do honestly and intelligently and to the best of your knowledge and ability.

Keep Out of Ruts.~Whether a man is just out of college or whether he has been many years in business, I would not think of employing him if he is a 'yes' man or if he is wont to rely simply on his offhand opinion. If he is willing to give his client the advice he thinks his client wants, regardless of conditions, or has reached the stage where he is unwilling to study and investigate a problem to the best of his ability, it is time that he retire and give a more energetic, honest, and competent man a chance. If you neglect some one factor that seems of little value, you will neglect matters of importance.

So long as I am willing to study a problem thoroughly, I am—professionally—just as young as the youngest of you. Yes, I am younger if you refuse to study and investigate a problem fairly and completely. Get to the bottom of every question that comes to you no matter how simple it may seem to be. Even if a large number of men of high standing take a point of view other than your own, when you are satisfied with your solution, stand by it fearlessly. But first be sure you are right.

Public Good Must Be First.~Remember this also: You are American citizens first, and engineers second. Any advancement of this Society and of our great profession must involve a benefit to the nation and its citizens or it will be a failure. At times we have to favor some things which personally we may be averse to, but in which we recognize benefits that ultimately will come to the public. Family and similar obligations have to have their due consideration but, speaking broadly, your allegiance must be first to your country and then to your profession. Our personal and professional improvement and advancement must be based upon the public good or the results desired will never be permanently accomplished.

While you young men are important to the profession and to this Society, the profession and the Society are much more important to you. Such relations must be mutual. You should consider the proposition as to whether you are doing your share in national, local, and professional advancement. It is easy to find fault with conditions and with other people when sometimes the fault lies within ourselves.

Friends and Associations Are Invaluable.~One of the greatest assets a man can have in this life is his friends. You might live on a desert island and be the smartest engineer that ever was created but you could accomplish nothing because there would be no opportunity. It is barely possible that all by yourself you may chance upon an assignment that will lead to your future success; but to get the best out of life you have to know people, you have got to know men in the profession, and they have got to know you. They must know you and your energy, your abilities, your integrity, and your dependability.

No man ever wrote a good paper or a good book but that he, more than any one else, was benefited by that writing. Knowledge is one of those things of which the more you give the more you get. Frequently the highest advancement comes with the most disinterested efforts to assist others and to advance our profession. Where can this be done so well as through your association with members of this Society and with its active work? Now, confidentially, engineering writing for the engineering societies or for the engineering press, if well done, is the best advertising that a man can obtain, for through such writing the profession and the public become aware of one's knowledge and experience; but if done for advertising only, it is usually a failure in this respect. Remember that the profession has a right to depend upon you, and you must depend upon the profession and upon the Society. Through the Society you will get a chance to do your share towards making this profession the success we all hope it will be, and you will share in that success.

You young men are the hope of the future. On you the progress of our nation and of our profession depends. Our hopes and our ambitions are bound up in you. We sincerely hope for you a great success.

"Look not mournfully into the past, it
comes not back again;
Wisely improve the present, it is thine.
Go forth to meet the unknown future with
A strong heart and a manly spirit."

Louis C. Hill
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Number 5

Notable Bridges in the United States

The Outstanding Features of Some Landmarks in Bridge Development

By R. N. Bergendoff

Member American Society of Civil Engineers
Assistant Engineer, Ash-Howard-Needles and Tammen, Kansas City, Mo.

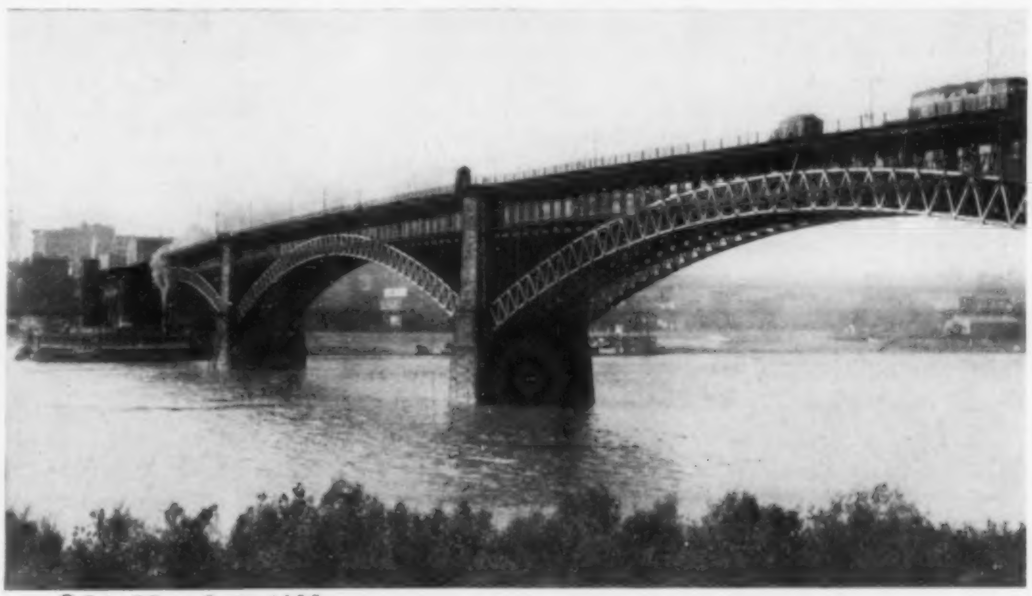
What makes a bridge notable from an engineering standpoint? The more important of the characteristics listed by Mr. Bergendoff are the part it may have played in the development of the country; the length, weight, or vertical clearance of the principal span; the use of new materials; novel methods of constructing foundations and erecting superstructures; and such general aspects as cost, quantity of materials, and over-all length. It is significant that within a hundred years maximum span lengths have increased from 580 to 4,200 ft (the length of the Golden Gate span now under construction), and tower loads from 650 to 68,300 tons. Expenditures have risen in even greater proportion. The present record is held by the San Francisco–Oakland Bay Bridge, which it is estimated will cost $77,000,000. But large and costly structures are not the only notable ones, and certain bridges of more common dimensions represent almost perfect solutions to crossing problems, with respect to both type and beauty. The article is abstracted from Mr. Bergendoff's address of October 8, 1936, before the Kansas City (Mo.) Section of the Society.

To attempt to name the notable bridges of the United States, segregating them by setting them off in a list, would be almost as difficult as to make a list of the true causes of the depression. The feature of a structure which to one person would be sufficient reason for classifying it as "notable" may not appeal to another. Certainly there may be design or construction problems involved which would attract the serious interest and study of an engineer, while to a layman the structure may be "just another bridge."

From an engineering standpoint a bridge may be notable because of its type, the length of its spans, the use of a new material in its construction, the depth of its foundations, the height to which its superstructure rises, its clearance above water level to provide for navigation, its over-all length, its cost, the unique features of its design, the methods used in its construction, or the records in bridge construction it has broken.

Four Epoch-Making Bridges

During the last half of the nineteenth century four bridges were completed that have made history. The largest of these, the gigantic cantilever bridge of Sir John Fowler and Sir Benjamen Baker over the Firth of Forth in Scotland, with its two 1,700-ft spans, its majestic appearance, and its outlines clearly expressing the cantilever principle, will long remain an outstanding bridge. The other three, all in the United States, were the Eads Bridge in St. Louis over the Mississippi River, the Brooklyn sus-



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The Eads Bridge Over the Mississippi at St. Louis, Completed in 1874, Is the First Steel-Truss Bridge Ever Constructed

pension bridge of the Roeblings in New York, and the Missouri River Bridge at Glasgow, Mo.

Of suspension type, with a span 1,595.5 ft in length, the Brooklyn Bridge was completed in 1883 at a cost of $15,000,000. It has been estimated that in its time more was written about this bridge in the technical and popular press than about any other ever built. It was the crowning achievement of John A. Roebling, M. Am. Soc. C.E., who unfortunately did not see the fulfillment of his dream, as he succumbed to a foot injury the first year of its construction. The work was completed under the direction of his son, Washington Roebling. The latter stayed under compressed air for 24 hours while assisting in fighting a fire in one of the caissons, and was carried out a paralytic invalid for life.

A.I.S.C.

THE BAYONNE BRIDGE OVER THE KILL VAN KULL, WITH A SPAN OF 1,652 FT, IS THE LONGEST STEEL ARCH IN THE WORLD

The Eads Bridge, completed in 1874 after difficulties equal to those experienced on the Brooklyn Bridge, is of interest because it involved the first use of steel in truss-bridge construction. The 520-ft center span and the two 502-ft side spans, built with ribs of chrome-steel tubes, were also the longest fixed-end metal arches. Together with the Brooklyn Bridge, the Eads Bridge was one of the first in which pneumatic caissons were used for pier construction. Little was then known as to how to combat the fatal effects of working under compressed air. As a consequence, there were 119 cases of so-called caisson disease, and 14 men lost their lives.

The Missouri River Bridge at Glasgow, an epoch-making structure, although replaced in 1902, was built by Gen. William Sooy Smith for the Chicago and Alton Railroad. When it was completed in 1879, the first all-steel bridge to be built, few believed it would ever stand up under traffic.

The Hannibal Bridge in Kansas City, completed in 1869; the Memphis Bridge, completed in 1893; and the Sixth Street Bridge at Pittsburgh, constructed in 1819 and rebuilt three times, are examples of some of the older bridges which have been notable for their influence on the growth and development of the cities in which they are located.

SUSPENSION AND CANTILEVER SPANS

Among the types of spans by which bridges are classified, the suspension leads in span lengths. It is particularly striking because of its graceful, slender lines. The United States now claims the world's longest span, and in addition has 16 bridges with suspension spans exceeding 1,000 ft in length. The longest of these, the 4,200-ft span of the Golden Gate Bridge, is $2\frac{1}{3}$ times the length of the 1,800-ft cantilever span of the Quebec Bridge, which is the longest of any other type. The Brooklyn Bridge remained among the longest suspension spans for over 30 years, until the 1,750-ft span of the Philadelphia-Camden Bridge was completed in 1926. Since that year the record length has been thrice broken—by completion of the 1,850-ft span over the Detroit River in 1929, the 3,400-ft span of the George Washington Bridge over the Hudson in 1931, and the 4,200-ft span now being constructed over the Golden Gate.

Within a hundred years the maximum span has lengthened from 580 to 4,200 ft, with loads on towers increasing from 650 to 68,300 tons. Will the span-length record soon be broken again? With the dreams of yesterday transformed into the realities of today, who can predict what the future will bring? Fifty-seven years ago the leading engineers of the day predicted that the 315-ft steel spans of the Glasgow Bridge over the Missouri would not stand up. Today new materials with greater strength and less weight are already competing with those formerly in use. Aluminum, for example, is attracting widespread attention. New processes of fabrication, of which welding has already gained wide application, are revolutionizing design and construction. The two 36.5-in. cables of the Golden Gate Bridge have an increased strength per square inch of 55 per cent over the four 15.5-in. cables of the Brooklyn Bridge, indicating the increase in wire strength alone. The maximum practical limit of length for the suspension span is now about 10,000 ft, and for the cantilever span, about 3,000 ft. When metal of greater strength is produced, these limits will be increased.

The cantilever is especially adaptable to long spans over deep water because of the saving effected in falsework. Like the simple span, the cantilever permits slight settlement of supports without serious effects on the stresses in the truss members. The longest cantilever span in the United States is exceeded in length by the 1,800-ft span of the Quebec Bridge, and the 1,700-ft span of the bridge across the Firth of Forth. The 1,400-ft span of the San Francisco–Oakland Bay Bridge, the 1,200-ft span of the Columbia River Bridge at Longview, Wash., the 1,182-ft spans of the Blackwells Island Bridge in New York, the 1,100-ft span of the Carquinez Strait Bridge in California, the 1,050-ft span of the Cooper River Bridge in South Carolina, and the 825-ft span over the Mississippi River at Vicksburg, Miss., are the longest cantilevers in the United States.

One of the large cantilever structures now under construction, with a number of unique features of design, is the Neches River Bridge at Port Arthur, Tex. This has a 680-ft center span, providing a vertical clearance of 176 ft, and is designed to resist a 75-lb hurricane

wind. For a structure of such height it is readily seen that falsework would be very expensive, especially where foundation conditions are such as at Port Arthur, or where a deep stream necessitates the use of long piling to carry the temporary falsework.

Within the last twenty years the continuous span has gained favor. Particularly adaptable to short highway spans, it is being used extensively on the smaller structures. On longer spans it was first used for the two 775-ft spans over the Ohio River at Sciotoville. Since then, the Mississippi River Bridge at Cape Girardeau with two 771-ft spans, the three-span structure at Cincinnati, and the two 525-ft spans at South Omaha have been completed, among others.

With the development of other types, the lengths of simple spans have also increased. The longest of these, the railroad structure over the Ohio River at Metropolis, 720 ft long, is but 4 ft longer than the simple span of the highway bridge over the same river at Paducah, Ky.

With the introduction of automobiles, vast sums have been spent in the elimination of grade crossings and the construction of high-speed viaducts. The most outstanding of such structures is the Pulaski Skyway, a highway $3^3/_4$ miles long, built at a cost of $22,000,000 over the New Jersey meadows, west of New York City, with spans over the Hackensack and Passaic rivers. Opened in 1932, there was some doubt as to the amount of traffic it would be called upon to carry, and a considerable feeling that the 50-ft roadway provided was excessive. These fears were quickly dispelled, as the traffic became so great that trucks were prohibited.

ARCHES AND MOVABLE SPANS

Since its construction in 1917, the outstanding arch span in the United States has been the Hell Gate Arch, the work of the famous engineer, the late Gustav Lindenthal, Hon. M. Am Soc. C.E. This arch is outstanding not only from the standpoint of bridge design but also from that of bridge architecture. Its span of $977^1/_2$ ft was the longest steel arch in the world from 1917 until 1931, when the 1,652-ft span of the Bayonne Bridge over the Kill van Kull was completed with a span 2 ft longer than the Sydney Harbor Bridge in Australia (completed in 1932).

Concrete, which is strong in compression and lends itself readily to architectural treatment, has been found particularly adaptable to the arch type of bridge. The George Westinghouse Bridge at Pittsburgh, completed in 1931, with a center span of 460 ft, is the longest concrete span in the United States, although the French have constructed 600-ft spans with this material. However, one of the greatest concrete structures ever built

THE BRISTOL-BURLINGTON BRIDGE OVER THE DELAWARE RIVER
Its 540-Ft Lift Span May Be Raised in Two Minutes to Give a Clearance of 135 Ft

is in this country. This is the Lackawanna Railroad's majestic Tunkhannock Viaduct rising 240 ft above the creek level and having a length of 2,375 ft. The Arroyo-Seco Bridge in Pasadena, often called "Suicide Bridge," is one of the earlier concrete bridges well known for pleasing architectural treatment. As a concrete structure, the Twelfth Street Viaduct in Kansas City is outstanding in design and unusual in type.

Movable spans, which are so prominent in many crossings over the navigable streams of our country, have involved problems demanding skill and ingenuity in design and construction. The bascule type, operating on a trunnion or rolling on a segmental girder, the swing span rotating about a center pivot, and the lift span raised vertically between towers, each with its own particular use, has been constructed with long spans, heavy spans, and intricate details.

The Mississippi River Bridge at Fort Madison, with its 525-ft double-deck swing span, has a moving load of 10,000,000 lb. Four 75-hp motors provide the power for turning. The double-deck Michigan Avenue Bridge in Chicago is one of the well-known bascule spans in the country. A vertical-lift span of 540 ft has been built over the Delaware River at Burlington, N.J., and one of 544 ft over the Cape Cod Canal. These spans are equipped with machinery capable of lifting them in less than two minutes to give 135-ft clearance above the water. The Harlem River lift span of the recently

THE ARROYO-SECO VIADUCT AT PASADENA, CALIF.
A Concrete-Arch Structure with Pleasing Architectural Treatment

Lower Deck Telescoped Into Upper and Both Raised

Highway and Railroad Spans Both Down

Harriman Bridge Over the Willamette River at Portland, Ore.

completed Triborough Bridge has the largest floor area of any movable span built. Unique in design, the lower deck of the Missouri River Bridge at Kansas City may be raised for navigation without interrupting highway travel on the upper deck. The Oregon–Washington Railroad and Navigation Company's bridge over the Willamette River at Portland, Ore., is somewhat more complicated, being designed to permit either lifting its lower railway deck independently of the upper highway deck for the passage of small boats, or telescoping the lower deck into the upper and lifting both simultaneously to permit the passage of high-masted vessels.

SOME DIFFICULT FOUNDATION PROBLEMS

One of the most difficult problems involved in the construction of large bridges in localities where rock is not available for founding the piers is the design and construction of foundations. For the bridges over the Mississippi River south of Thebes, Ill., it has been necessary to rest the foundations on either sand or clay. The foundations for the combined railway and highway bridge at Vicksburg, founded in clay and sand at a maximum depth of 97 ft below low water, were sunk by the conventional method. The innovation here consisted of the introduction of fabricated steel boxes in the caissons in place of timber cribs.

As it is not possible for men to work under air pressures exceeding 55 lb per sq in., the piers on the Vicksburg Bridge were sealed at a depth requiring an air pressure of 53 lb per sq in.—the maximum ever used. At one time more than 400 "sand hogs" were employed in the caisson work. Although many of these men were novices, such care was taken to avoid accidents that not one fatality or permanent serious injury resulted from the air work. When compared with the loss of life on the Eads Bridge, it is evident that advances have been made in protecting against caisson disease, or "the bends," as it is commonly called.

As it was necessary to found the large piers of the New Orleans Bridge at a depth of 170 ft below Gulf level, sinking and sealing the caissons under air was out of the question. Instead, the process of open dredging through sand islands was used. The sand island method is effective in eliminating the tendency to overturn which is frequently encountered in sinking caissons, especially in deep water and soft material. This method was first used in California in 1929, on the Southern Pacific Bridge over Suisin Bay. It is also being used in the construction of the Neches River Bridge at Port Arthur, Tex.

The scheme involves the construction of a steel cylinder enclosing an area larger than the caisson to be sunk. After founding this shell with its bottom below the bed of the stream and the top well above high water, the enclosure is filled with sand. Then the caisson is sunk through the dry island by dredging. As the sinking proceeds, concrete is built up until the elevation is reached at which the base is to be founded. Besides the advantage of control, this method permits pouring all the concrete in the dry.

On the San Francisco–Oakland Bay Bridge another ingenious method of sinking was introduced. Here it was necessary to carry the piers to a maximum depth of 242 ft below the water line. After the caissons had been brought into position, the dredging wells were capped with steel-plate domes and air pumped into the watertight well cylinders, increasing the buoyancy of the caisson. Concreting was then started and the sinking controlled by dredging through a limited number of wells, from which the caps were removed. Tendency to overturn or move laterally was controlled by shifting the dredging operations from well to well.

VERTICAL CLEARANCE REQUIREMENTS

Since by Act of Congress of 1906, jurisdiction of all bridges over navigable streams was placed under the War Department, the vertical clearances provided for such structures are subject to its approval. These clearances are generally determined following public hearings for the purpose of establishing clearances satisfactory to navigation interests.

On the Missouri River, clearances of $52^1/_2$ ft above standard high water have become more or less standard. On the Mississippi River the clearances from St. Louis to Vicksburg have been accepted as 65 ft above mean high water. For deep-water navigation at New Orleans, a height of 135 ft above high water was required. But inasmuch as there is an 18-ft difference between Gulf level and high water, this clearance becomes 153 ft above mean Gulf level.

A clearance of 135 ft above high water is generally acceptable for crossings over the larger rivers near the sea. On the Neches River Bridge at Port Arthur, however, a 176-ft vertical clearance is being provided. The maximum vertical clearance, amounting to 210 ft, is established on the Golden Gate Bridge at San Francisco. For the George Washington Bridge over the Hudson a minimum clearance of 195 ft is provided.

The bridge which has the distinction of being the highest in the United States is that over the Royal Gorge. Its 880-ft span crosses the Arkansas River at a height of 1,050 ft above the water.

A number of structures are noteworthy because of their extreme lengths. The New Orleans Bridge, with a length of $4^1/_2$ miles of steel structures, is said to be the longest railroad bridge in the United States. The San Francisco–Oakland Bay Bridge can claim the distinction of being the longest highway bridge, having over 5 miles of main spans alone. It is also the first bridge with two adjacent suspended spans connected by a common anchorage.

With a total estimated cost of $77,000,000, the San Francisco–Oakland Bay Bridge again will break all records. The George Washington Bridge ranks second,

with a cost of $55,000,000. Other large structures have involved the following expenditures:

Triborough Bridge, New York City..	$44,200,000
Golden Gate Bridge, California......	37,000,000
Delaware River Bridge, Philadelphia.	35,000,000
Brooklyn Bridge, New York City....	15,212,000
Firth of Forth Bridge, Scotland......	16,135,000

To appreciate the enormous amount of material incorporated in the San Francisco–Oakland Bay Bridge,

A.I.S.C.

Emptying Sand in Counterweight Boxes After the Suspended Span Is in Position on the Carquinez Bridge

it has been estimated that there is enough steel and concrete for 35 large skyscrapers. There is enough timber in falsework and final construction to build 3,000 small homes, sufficient for a small city of 15,000 people.

SOME UNUSUAL ERECTION METHODS

Many bridges are notable because of the methods used in the erection of their superstructures. On earlier structures, a large proportion of the cost of erection of long spans was for the elaborate and costly falsework necessary. Ingenious methods have now been evolved, eliminating the necessity for expensive falsework. On the Hell Gate Arch, as on the Sydney Harbor Arch in Australia, the arch ribs were erected by tieing back to the abutments, which thus acted as anchorages. On the 540-ft lift span at Burlington, N.J., the towers and counterweight rope were utilized for supporting the truss while it was being erected by cantilever methods.

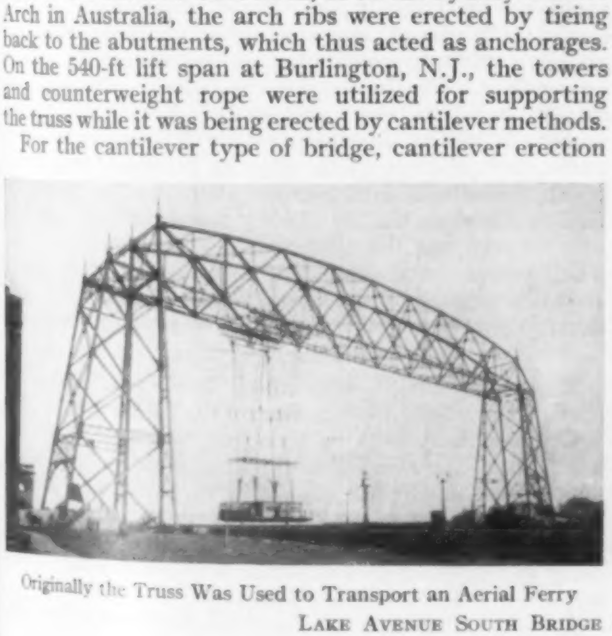
For the cantilever type of bridge, cantilever erection is readily adaptable, permitting construction by extending the trusses out from the piers. In the case of the Mississippi River Bridge at Vicksburg, this involved cantilevering from each pier a distance of $412^1/_2$ ft before the two trusses met in the center. For the Carquinez Straits Bridge, the 433-ft suspended span was erected on falsework along the shore, transferred to barges, and floated into position. By the use of sand boxes as counterweights, the span was raised to its final elevation. This method, known as "floating in," has been used to some extent for simple spans.

In rebuilding a structure it is often necessary to make provision for maintaining traffic or incorporating certain features of the old structure. A notable example of this was in the reconstruction of the Aerial Transporter at Duluth, Minn. This bridge, which is one of the few of its kind, originally consisted of two towers 130 ft high, surmounted and connected by a 394-ft truss, from which was suspended a platform car or aerial ferry which operated back and forth between the shores. In 1927 the bridge was reconstructed with a 384-ft lift span. Additional towers were built inside the old towers and extended 40 ft higher. Utilizing the counterweight and counterweight ropes of the new lift span, the existing truss was next raised 40 ft to a position on top of the new towers. The lift span was then built in its up-position so as not to hinder navigation. Upon completion, it was lowered and put into operation.

So far I have classed as "notable structures" only large structures. In our modern life there has been a tendency for our sense of values to become warped through considering only large or costly things as notable. With this tendency we often fail to appreciate what is being done in the matter of little things.

To the bridge engineer a structure is not notable unless the finished product is the best solution of the problem. It has been my good fortune to have been associated with the design and construction of some of the large structures which have been mentioned, but the satisfaction and feeling of accomplishment derived from working out problems presented on some small bridges has been equally great.

In this connection attention is directed to the advance being made in the design of the more common structures built under the direction of our state highway departments. Such excellent work has been done by these departments that the specifications of the American Association of State Highway Officials have come to be accepted more or less as standard. Some of these latter structures, although of no great length and built at moderate cost, represent almost perfect solutions to crossing problems, with respect to both type and beauty.



Originally the Truss Was Used to Transport an Aerial Ferry

The Bridge as Reconstructed, with a 384-Ft Lift Span

Lake Avenue South Bridge Over the Duluth Ship Canal

The Flood of 1937 in the Ohio Valley

Cause, Magnitude, and Possibility of Recurrence; General Plan for Future Protection Works

By S. J. Horn

Captain, Corps of Engineers, Assistant to the District Engineer,
U. S. Engineer Office, Louisville, Ky.

For three grim weeks last winter the attention of the entire nation was centered upon the Ohio Valley, where a mighty river was laying siege to a hundred cities and towns. Marietta, Parkersburg, Portsmouth (the invincible), Cincinnati, Louisville, Paducah—one after another these centers of population were evacuated in whole or in part as the river, unhurried and relentless, made its way into their streets. In the present article Captain Horn wastes little time in retelling the story of the flood itself. His interest is primarily in its cause and in the engineering deductions that may be drawn from it. He points out that the 1937 flood provides a new yardstick for measuring disasters of this kind in the Ohio Valley, and a new basis for determining the adequacy of the proposed control works. He calls attention to the basic differences between the problems of the Ohio and those of the Mississippi. Finally, he stresses the importance of making haste slowly in the design of flood-protection works for any stream, and the need for a high degree of "flexibility" in the final plan.

About the middle of January 1937 there existed in the eastern part of the United States a peculiar, and fortunately rare, combination of meteorological conditions which produced excessive rainfall over the watershed of the Ohio River. These conditions remained essentially unchanged until January 25, resulting in a period of unprecedented rainfall in the Ohio Valley and causing a flood that exceeded all previous records on the Ohio from the mouth of the Kanawha River to Cairo, and on many of the tributaries.

Precipitation throughout much of this area had been above average in December and continued above average for the first twelve days of January. Consequently the very heavy rains that followed fell upon a ground surface already nearly saturated, and the resulting rates of runoff were very high.

By about January 12 a high-pressure area had been built up covering the Southern Atlantic States and centered near Bermuda. This high was balanced by another high-pressure area centered near the Upper Mississippi. Between these two highs lay a low-pressure "trough," extending from southwest to northeast and covering most of the Ohio Valley. Storm centers, heavily laden with moisture from the Gulf of Mexico, were drawn in a northeasterly direction through this trough and came in contact with masses of cold air in the Ohio Valley, which caused the moisture to be condensed. Unusually heavy precipitation was the natural result.

These storms followed each other in rapid succession so that rainfall was almost continuous. For example, in Kentucky, January 16 was generally fair and on the 19th only about half the stations reported rainfall. With these two exceptions precipitation was recorded daily by nearly all Kentucky stations from January 13 to 25, inclusive. At Murray, Galloway County, Kentucky, 5.88 in. in 24 hours was reported on January 21, and Earlington, Hopkins County, recorded the high for the month at 22.97 in.

On the 26th the meteorological set-up described was broken up and the period of heavy rainfall ended. Although some rain fell between that date and the end of the month, it was not in sufficient quantity to affect the flood crest appreciably. Table I shows the recorded precipitation at various stations throughout the watershed of the Ohio River. The monthly totals have been broken up to show the amount that fell during each of the periods previously mentioned. In this connection see also Fig. 1.

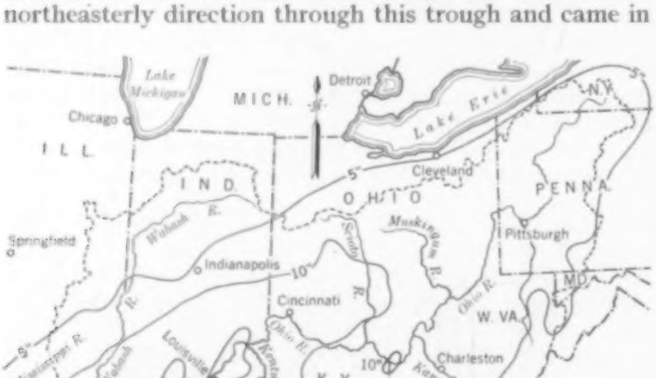


Fig. 1. Precipitation in the Ohio River Basin for the Period January 13–25, Inclusive, 1937

Naturally, so large an amount of rain falling in a period of less than two weeks, and on a ground surface already nearly saturated, was immediately reflected by a rapid rise of river levels. Flood stages were reached and rapidly passed, and as the rain continued to fall it was impossible to predict the ultimate stage that might be reached. On January 23 it turned cold, and the rain changed to sleet and snow. Runoff slowed up materially when the temperature fell below freezing, and a crest of 52 ft on the gage at Louisville was thereupon predicted. However, that night the temperature rose and on the 24th heavy rain again fell, carrying into the streams the sleet and snow of the day before. The river resumed its rise at an alarming rate, rising as much as 0.3 and 0.4 ft per hr at Louisville and culminating in the final crest of 57.1 ft on the gage there.

A "Down River" Flood

The precipitation was much heavier in the lower part of the valley than it was on the headwaters. This was particularly true in the early stages of the flood. The bulk of the rain fell in the immediate vicinity of the Ohio River and in the basins of the Kentucky, Green, Cumberland, and lower Tennessee rivers. Heavy flooding was experienced on the Wabash River but this was early in the flood period. The Wabash was falling before the flood crest reached Louisville.

Because of the distribution of rainfall, flood stages were

reached in the lower river before they occurred in the upper. For this reason it has been referred to as a "down river" flood, and the belief has arisen in some quarters that the flood wave traveled up the river instead of down. It has also been reported that the levees of the lower Mississippi were responsible for this "piling up" in the lower Ohio and raised flood stages to such an extent that they caused severe damage which would not otherwise have occurred. The question has in fact been asked whether the Mississippi levees did not cause excessive flood heights at Cincinnati, notwithstanding the fact that the elevation of the river bed at Cincinnati is approximately 158 ft higher than at Cairo. These beliefs have no basis in fact. The earlier flood stages in

Table I. Rainfall in Inches, January 1937

Station	1st to 12th	13th to 25th	26th to 31st	Total for January
Ohio River:				
Portsmouth, Ohio	4.03	8.18	0.27	12.48
Maysville, Ky	4.23	10.08	0.40	14.71
Cincinnati, Ohio	1.78	11.74	0.16	13.68
Madison, Ind.	2.36	15.13	0.34	17.83
Louisville, Ky.	3.70	15.06	0.41	19.17
Owensboro, Ky.	3.97	13.32	0.30	17.59
Evansville, Ind.	2.21	12.36	0.21	14.78
Uniontown, Ky.	2.89	14.40	0.10	17.39
Paducah, Ky.	3.76	13.39	0.38	17.53
Kanawha River:				
Charleston, W. Va. . . .	2.06	5.98	0.42	8.46
Muskingum River:				
Coshocton, Ohio	1.52	9.80	0.21	11.53
Scioto River:				
Circleville, Ohio	2.17	10.79	0.32	13.28
Delaware, Ohio	1.13	9.10	0.15	10.38
Kentucky River:				
Frankfort, Ky..	4.13	12.23	0.41	16.71
Wabash River:				
New Harmony, Ind. . .	2.75	13.35	0.18	16.28
Terre Haute, Ind.	2.83	5.99	0.17	8.99
Green River:				
Calhoun, Ky.	3.82	16.20	0.49	20.51
Bowling Green, Ky. . . .	3.66	15.61	1.43	20.70
Cumberland River:				
Nashville, Tenn.	3.35	10.22	1.18	14.75
Dover, Tenn.	2.15	21.20	0.50	23.85
Tennessee River:				
Johnsonville, Tenn.. . . .	3.89	19.23	0.39	23.51
Savannah, Tenn.	6.10	7.54	0.30	13.94

the lower river were due to the heavy discharges of the lower-river tributaries, which preceded the flood wave on the main stream. While it is doubtless true that the early filling up of the lower river resulted in flatter slopes and smaller discharges for corresponding gage heights, the crest actually proceeded downstream in a more or less regular manner. Table II shows the dates on which flood stages and flood crests were reached at various points. In Tables III and IV, 1937 crests and maximum discharges are compared with those of previous great floods, for various points on the Ohio.

It will be noted that the flood wave crested on the same day at Point Pleasant and Portsmouth and that the crest occurred a day earlier at Cincinnati. The explanation for this lies in the effect of the flow of tributaries entering the Ohio in that vicinity. A second crest occurred at Pittsburgh on January 26, and reached a gage height of 34.5 ft there. This was 1.6 ft higher than the earlier crest which occurred on the 23rd, but this second flood wave dissipated itself rapidly and caused no damage below. The second crest occurred on the same day as the crest at Cincinnati and while the river was falling at some points between. It was caused by precipitation that fell too late to affect the crest of the main flood wave.

Comparison with Other Floods of Record

A comparison of the records of the 1937 flood with other major floods indicates the close relationship between these great floods and the unusually heavy rainfall that causes them. Popular fancy has busied itself of late in assigning responsibility for the recent flood to a variety of factors. However, the fact clearly remains that unusual quantities of water entering a stream in the form of runoff from unusually heavy rainfall must be reflected in unusual river stages. The two greatest previous floods in the Ohio Valley occurred in February

Railroad Yards at Louisville, Ky., During 1937 Flood

At the Crest of the Flood, the Water Stood 8.6 Ft Higher Than When This Picture Was Taken

1884 and March–April 1913. In the 12-day period prior to the crest of 1937 at Louisville a total of 12.26 in. of rainfall was recorded on the Louisville gage, as compared to 8.02 in. in 1884 and 6.33 in. in 1913. The average rainfall over the entire Ohio River drainage area for the same 12-day periods was 4.82 in. in 1884, 4.72 in. in 1913, and approximately 8.0 in. in 1937. Runoff in inches on the drainage area above Louisville was 5.94 in 1884 and 4.56 in 1913, as compared to 7.88 in 1937, and the maximum discharges at Louisville were 944,000,

Table II. Dates on Which Flood Stages and Crests Were Reached by the 1937 Flood, with Corresponding Gage Heights

Place	Miles Below Pittsburgh	Flood Stage		Crest Stage	
		Gage Height	Date Reached	Gage Height	Date Reached
Pittsburgh, Pa.	..	25.0	Jan. 21	32.9 34.5	Jan. 23 Jan. 26
Point Pleasant, W.Va. .	265	40.0	Jan. 18	62.7	Jan. 27
Portsmouth, Ohio . . .	355	50.0	Jan. 18	74.2	Jan. 27
Cincinnati, Ohio	470	52.0	Jan. 18	80.0	Jan. 26
Louisville, Ky	607	28.0	Jan. 16	57.1	Jan. 27
Evansville, Ind.	792	35.0	Jan. 11	53.8	Jan. 30
Paducah, Ky.	934	39.0	Jan. 10	60.8	Feb. 2
Cairo, Ill.	980	40.0	Jan. 10	59.6	Feb. 3

902,000, and 1,206,000 cu ft per sec, respectively. The corresponding crest heights on the upper gage were 46.7, 44.9, and 57.1.

Although stages reached this year were higher than any previously recorded at most points on the Ohio River, there is some evidence that comparable flood discharges have been experienced in the valley in the past. The floods of 1762 and 1763 are described in a letter written by Col. Henry Bouquet, an English Army officer who was in command of Fort Pitt, which then stood on the site of the present city of Pittsburgh. It is probable that Colonel Bouquet witnessed these two floods. The flood of 1763 appears to have reached a stage of about 41 ft on the present gage at Pittsburgh. No crest higher than this was recorded until March 17, 1936, when a

stage of 46 ft was reached. There is an undocumented report of a flood which occurred about 1773 and which probably approximated from 75 to 76 ft on the present Cincinnati gage. If this flood did occur, it was probably as large as, or larger than the flood of 1937 at Cincinnati, although the latter reached about 80 ft on the Cincinnati gage. Had the 1937 flood occurred when the valley was still in its primitive state and before man-made structures had encroached upon the flood plane, it is doubtful whether it would have exceeded the crest stage of the 1773 flood.

U. S. Army Air Corps

THIS SCENE WAS DUPLICATED MANY TIMES OVER ALONG 700 MILES OF RIVER

Metropolis, Ill., in February 1937

Naturally, a flood of this magnitude, occurring in a highly developed area, assumes the proportions of a major disaster. Months must pass before an accurate compilation of the loss and damage suffered can be completed. The highly industrialized part of the valley between Huntington and Cincinnati sustained heavy losses, while in the lower valley the inundated area was wider in extent than for any previously recorded flood. Louisville and Paducah, Ky., were almost completely inundated. Smaller towns were in some cases entirely submerged. Heavy losses of animals and stock feed occurred in the agricultural area. Communities such as Portsmouth, Ohio, Lawrenceburg, Ind., Shawneetown and Mound City, Ill., found their levees and flood walls inadequate. Cairo, Ill., alone was successful in keeping the waters outside its local protection works.

TABLE III. MAXIMUM FLOOD DISCHARGES OF GREAT OHIO RIVER FLOODS (CU FT PER SEC)

STATION	1884	1907	1913	1936	1937*
Pittsburgh, Pa.	410,000	440,000	370,000	550,000	320,000
Wheeling, W.Va. (Dam 12)	430,000	430,000	370,000	470,000	380,000
Marietta, Ohio	410,000	490,000	600,000	460,000	500,000
Parkersburg, W.Va.	420,000	500,000	590,000	460,000	530,000
Pt. Pleasant, W.Va.	590,000	490,000	620,000	490,000	620,000
Catlettsburg, Ky. (Dam 29)	640,000	550,000	670,000	530,000	640,000
Portsmouth, Ohio	650,000	560,000	670,000	530,000	650,000
Maysville, Ky. (Dam 33)	660,000	580,000	670,000	550,000	770,000
Cincinnati, Ohio	680,000	600,000	660,000	570,000	930,000
Louisville, Ky.	790,000	710,000	770,000	660,000	1,200,000
Evansville, Ind.	670,000	630,000	680,000	640,000	1,300,000
Paducah, Ky.	1,500,000	1,150,000	1,500,000	1,100,000	1,800,000

* Preliminary field computations, subject to revision.

Engineering operations during a flood of this character fall into three categories. These are the safeguarding of existing navigation works, the collection of technical data, and life-saving and relief operations. In the absence of a complete and coordinated system of flood-control works in this valley, emergency protection work is limited to assistance in holding local levee lines and flood walls previously constructed by riverside communities. In general, during the recent flood the extreme stages so far overtopped the crown heights of these local protection works that no emergency raising of levees or flood walls could have been successful. The spectacular exception is the city of Cairo, where the levees and flood walls were successfully held throughout the flood period. It should be recalled that this article is restricted to the Ohio River, and that these remarks do not apply to the Lower Mississippi River, where the levee lines were held throughout the flood.

Neither the steps taken to safeguard existing navigation works nor the essential operation of collecting technical data such as discharge measurements and gage records needs discussion here. Suffice it to say that every effort was made to secure the data that are an essential part of all hydraulic calculations incident to river engineering. Discharge measurement parties operated under very considerable physical difficulties. The breakdown of telephone and telegraph lines hampered to a great extent the transmission of instructions to party chiefs. Furthermore, the difficulties of travel by land and river impeded the work. Despite these hindrances, however, a great amount of valuable data was secured, and the operations of these parties were in the main successfully carried on. It may also be of interest to note that steps were taken to procure a complete set of aerial photographs covering the entire valley of the Ohio River during the period of the flood crest. The area covered was sufficiently extensive to permit the determination of the limits of flood areas. The taking of these photographs was so timed that, generally speaking, crest stages were photographed throughout the length of the river.

The determination of high-water marks and the "tie-in" of these elevations to existing data are very important operations. They are done automatically, of course, at all gaging stations. However, the data thus secured are not sufficient. It is necessary to supplement them by so-called "high-water-mark" surveys, which are initiated as soon as is practicable after the flood has crested. The collection of these data was undertaken at the earliest possible moment and is being pushed vigorously. The work falls into two distinct phases—the location of the actual high-water marks, and the "tie-in." The location is done prior to the "tie-in," and every effort must be made to mark these elevations by permanent metal markers before the traces of the high water are dimmed or obliterated. After the first essential work has been completed, the "tie-in" to the existing datum can be done in a more leisurely manner.

TABLE IV. COMPARISON OF CREST ELEVATIONS OF MAJOR FLOODS OF THE PAST

PLACE	FEB. 1884	MARCH 1907	MARCH–APRIL 1913	MARCH 1936	JAN.–FEB. 1937
Pittsburgh, Pa.	36.5	38.7	33.6	46.0*	34.5
Wheeling, W.Va.	52.6	49.6	50.6	55.5*	48.7
Parkersburg, W.Va.	53.9	51.6	58.9*	48.0	55.4
Huntington, W.Va.	64.5	57.3	65.3	58.6	69.1*
Portsmouth, Ohio	66.3	60.8	67.9	59.2	74.2*
Cincinnati, Ohio	71.1	62.1	69.9	60.6	80.0*
Louisville, Ky.	46.7	36.0	44.9	36.5	57.1*
Evansville, Ind.	48.0	43.8	48.4	44.4	53.7*
Paducah, Ky.	54.2	42.3	54.3	†	60.8*

* Maximum recorded flood crest.
† Not available.

Emergency operations incident to evacuation and relief engaged the greater part of the engineer force and equipment. A very considerable number of river craft were collected on the lower river, and performed excellent service during the period when evacuation of personnel and property from the inundated areas was the first consideration. Later a river service was placed in operation for the purpose of transporting emergency relief supplies to localities whose road and rail communications had been cut off by the high water. This work was carried on in cooperation with the Red Cross.

The normal distribution of Engineer Department operating personnel was found to be of particular advantage during the rescue stage. The several sub-offices located along the river, and the navigation locks, which are at fairly close intervals, all served as centers for this activity. Most of the operating personnel have had a great deal of experience with river conditions and have been through other floods in the past. Their experience was of great value in the emergency operations.

Small boats were of course best for the actual rescue work. Towboats with barges capable of handling quantities of people and personal property served as bases of operation for the rescue fleets where the work had to be carried on at a distance from relief centers. Swift currents created a great demand for power boats of any description, but in the lower river, where rough water was encountered, inboard motors were preferable to outboard motors.

The engineering deductions to be drawn from this flood fall into two categories. First, the flood provides a new yardstick by which to measure disasters of this kind in the Ohio River valley. Second, it provides a practical basis for determining the adequacy of the flood-control works proposed. The principal weakness of our river hydrology studies in the United States has been the comparatively short period covered by stream-flow records and the relatively small number of major floods included in these records. The factual data gained from the 1937 flood are therefore of great value.

WHISKEY KEGS WERE THE PONTOONS FOR THIS FLOATING BRIDGE, USED TO EVACUATE REFUGEES FROM DOWNTOWN LOUISVILLE

Built Under the Supervision of Engineer Reserve Officers. Flood About 8.6 Ft Below Crest

ARE GREATER FLOODS TO BE EXPECTED?

The size of this flood has caused much speculation as to whether a similar one may be expected in the near future, and also whether the recent disaster marks the extreme flood danger that may be anticipated. As to frequency, it is impossible, of course, to give a definite and final answer. Past records indicate that no such flood has occurred within the past 100 years. Fragmentary and partly undocumented reports indicate that a flood of comparable size may have occurred within about the past 175 years. However, from data now at hand, it appears that the frequency of this flood is not less than once in every 150 to 175 years, and it is probable that it occurs even less often than that. However, it must be recognized that actual flood frequencies are far from uniform, although average frequencies over a long period of time may approach uniformity. This must be considered in the planning and design of flood-control measures. I believe it fair to assume that any flood-control or flood-protection works should be constructed with a view to protecting against the greatest flood that is believed likely to occur, at least once during their lifetime.

AFTER THE FLOOD

Damage in the Residential Area of Jeffersonville, Ind.

The question as to whether the flood of 1937 marks the maximum which can occur can be answered quite definitely in the negative. Greater floods are possible in the Ohio Valley. The flood of 1937 was caused by precipitation concentrated generally south of the Ohio River and below the mouth of the Kanawha. On the other hand, the flood of 1907 was a headwater flood caused by heavy precipitation in the upper tributaries, while that of 1913 followed precipitation concentrated in the valley generally north of the Ohio. It is obvious that, had the severe precipitation of 1937 occurred without loss of intensity over a wider area, a flood approaching a combination of the 1907, 1913, and 1937 discharges might have occurred. While it is true that an increase in the area subject to severe precipitation may be expected to be accompanied by a decrease in the average rainfall over the entire area, it is entirely probable that the net result may be a greater total runoff, and consequently greater flood heights. This is particularly true if the heavy precipitation occurs first in the upper part of the valley and later in the lower part, so that the lower tributaries add their maximum flow at about the time of the main flood wave instead of generally preceding it as they did this year.

It is believed that a more prolonged precipitation was possible in 1937. Also, melting snow, a contributing factor in so many floods, was conspicuously absent this year. Had either of these conditions obtained, flood heights would have been increased accordingly.

In planning flood-control measures, these factors must of course be taken into consideration. The flood heights used as a basis for flood-control design should preferably be those computed for a "super flood," which provides for conditions more unfavorable than those which have occurred in the past.

PROTECTIVE WORKS MUST BE CAREFULLY PLANNED

Past floods have invariably been followed by the presentation of large numbers of plans which have for their aim the prevention of similar disasters. This will probably be equally true of the recent Ohio River flood. Many of these plans possess characteristics which appear on the surface to be very engaging. Sometimes they capture the public imagination. No such plan is worthy of serious consideration unless it is based upon the tedious, detailed, and comprehensive study which must be the basis for a sound engineering plan. The new and novel features of a hastily prepared plan usually cease to be new and novel after the necessary detailed study has been made to demonstrate their value. There is no short cut to success in this matter. This has been found to be true in all the flood-control projects of which I have any knowledge. A sound, feasible plan cannot be taken out of a hat like a rabbit.

LOUISVILLE AT THE CREST OF THE 1937 FLOOD

Detailed study of the flood problem in the valley of the Ohio River has been carried on since 1929 under the authority of an Act of Congress which made these studies the responsibility of the Engineer Department. Prior to 1929, intermittent studies of flood control had been made by the Department since 1913. A comprehensive plan for the control of floods in the Ohio Valley was submitted in 1933 and, after review, was published in 1935. The main question for consideration now is the adequacy of this plan as a defense against the flood menace which the events of 1937 have shown to exist.

The report submitted in 1933 considered a system of 88 reservoirs, located on tributaries of the Ohio River and providing approximately 19,000,000 acre-ft of storage. These reservoirs would afford a great amount of protection along the tributaries on which they are located. Operated collectively, and in accordance with a definite and well-coordinated plan, they would afford an appreciable amount of control on the Ohio River itself. However, the effect of these reservoirs decreases as the mouth of the river is approached. Conservative estimates indicate that this system would have reduced the recent flood by about 5 to 8 ft at Cincinnati and 2 to 3 ft at Louisville. It is therefore apparent that a reservoir system alone cannot be counted on to give complete protection from major floods. It must be supplemented by some other method if serious flood damage is to be prevented.

Some small benefit might be obtained by improving the river channel at certain locations in order to better its hydraulic qualities. However, the character of the valley is such that the cost of substantial lowering of flood heights by this method would be prohibitive. Nor does the valley lend itself to the use of diversion channels, or floodways, as does that of the Mississippi.

The report referred to therefore proposed to furnish the additional protection needed for towns and cities by levees. The topography of the valley is such that most of the communities have high ground in their rear, and protection can be furnished by river-front levees or sea walls tying in to this higher ground. In a few cases, particularly on the lower river, where the ground surface is flatter, ring levees to protect on all sides would be needed.

The plan did not contemplate levees for the protection of agricultural lands, as has been done so extensively along the Mississippi. The great length of levees that would be required would be prohibitively expensive. Also it would shut off large pondage areas, which are now subject to overflow in extreme floods, with a resulting increase in river stages. Because of the topography, there is less danger that rural inhabitants will be cut off from high ground by rising waters than in most of the Lower Mississippi Valley.

THE IMPORTANCE OF FLEXIBILITY

In the consideration of any flood-control plan, one principle must be observed wherever possible. For lack of a better term this may be defined as "the principle of flexibility." By this it is meant that the system should be flexible both in construction and in operation. The various works should be so planned that their development into a more extensive and elaborate system is both possible and logical. They should also be capable of operation under widely varying flood conditions. A system of tributary reservoirs serves a dual purpose. The reservoirs provide flood control in the tributary basins in which they are located. Furthermore, they can be operated so as to obtain the greatest possible stage reductions in the main river under varying conditions of rainfall. They are flexible in that they do not present any obstacle to the extension of the system, since additional reservoirs can be constructed if and when deemed advisable.

A review of the floods of 1907, 1913, and 1937 demonstrates that the locations of the areas of heavy precipitation may vary within comparatively wide limits. In fact, these areas may shift a considerable distance during one flood period. Thus, a widespread distribution of reservoirs is necessary for adequate control. Careful studies of probable conditions must be made as a basis for the design of outlet works and spillways for the individual reservoirs.

Although flood control on the Ohio River has been directly under the Engineer Department only since 1928, that agency has been in charge of the improvement of the river for navigation since about 1825. Many of the earliest records are not complete, but accurate and comprehensive data have been compiled on stream flow for much of that period. These data cover not only the Ohio River but many of the tributaries, and have been invaluable as a basis for the study of flood control in the valley.

Geology of Dam Sites in Hard Rock

Dealing with Igneous, Metamorphic, and Certain Sedimentary Varieties

By Warren J. Mead

Affiliate American Society of Civil Engineers
Professor of Geology, Massachusetts Institute of Technology, Cambridge, Mass.

In planning for a dam, a working knowledge of the geological features of the site is indispensable to the hydraulic engineer, who seeks to obtain this information by means of core-boring, churn-drilling, wash-boring, and geophysical prospecting, among other methods. The important phases of such exploration are described by Professor Mead in the forepart of this article. Taking up the principal types of rock encountered in dam construction, he next discusses those physical properties which are of importance to the engineer, including bearing strength and structural defects, resistance to sliding, water-tightness, treatment usually necessary in preparing foundations, and resistance to weathering. The accompanying article, dealing with these properties in igneous and metamorphic rocks, sandstone, and limestone, represents the first part of Professor Mead's paper presented on September 10, 1936, at Washington, D.C., before the Second Congress on Large Dams.

Since the technical feasibility of building a dam and the type and design of the structure are principally dependent on the geological features and conditions at the site, a thorough investigation of these features and an understanding of their engineering significance are essential. The fields of the engineer and geologist overlap in a manner that requires close cooperation and mutual understanding.

Adequate surface and subsurface exploration of foundation and abutment materials should be made, together with investigations of their physical properties. Surface outcrops should be mapped and studied as a means of securing a three-dimensional picture of the geology, to serve as a basis for laying out subsurface exploration. Exploratory surface excavations in the form of test pits and trenches, although of great value, are frequently overlooked. In many instances bore holes have been drilled where less expensive test pitting and trenching would have yielded better information.

EXPLORATION BY CORE-DRILLING

Modern practice employs core-boring wherever core recovery is feasible. For proper interpretation, maximum possible core recovery is essential. Close supervision is therefore imperative, as drill operators are prone to focus their attention on the boring of the hole rather than on the sample recovered.

Holes should be carefully logged and an adequate description should be written of the condition of the material at the time of recovery, as certain materials change rapidly in appearance and deteriorate with time. Other pertinent records should be kept, in particular regarding the behavior of water in the hole during drilling, as loss or flow of water yields important evidence of openings in the rock.

Drill Core Should Be Carefully Labeled and Stored
An Excellent Method of Filing Used at Bluestone Reservoir

Core should be placed in substantial boxes, plainly labeled. In the case of core from steeply inclined sedimentary strata, it is important that the orientation of each piece be preserved. The top of each piece should be suitably marked. Core should be protected from the weather, and any loss or failure to recover should be noted. Core removed from boxes for any purpose should be replaced by markers bearing the date and reason for such removal.

Careful consideration should be given to grouting exploratory core drill-holes at the completion of each hole, as valuable information regarding the existence of openings in the rock can be gained in this manner. This information is in some ways superior to that obtained by pressure or pumping tests. It is frequently difficult to do such grouting at a later date because casings are usually pulled out and many of the holes are in areas disturbed by excavation. Grouting pressures should not be great enough to enlarge openings by lifting the rock. A pressure of 1 lb per ft of depth is probably a safe maximum.

A valuable recent contribution to exploration methods is the large-diameter core drill, which permits the geologist or engineer to enter the hole and examine the exposed section of the rock in place. These large-diameter holes have been effectively employed at Norris Dam, at the Tygart River and Bluestone dams in West Virginia, at Fort Peck Dam in Montana, and at the site of the Possum Kingdom Dam in Texas.

Drilling is accomplished by a rotating cylinder employing shot as a cutting medium or, in soft rock, steel or hard-alloy cutting teeth. The core is broken loose from the bottom of the hole by small charges of explosive inserted in the bottom of the cut, and is lifted by a wedge device inserted in a small-diameter bore hole drilled in its axis. Where the material is too friable to permit extraction of a solid core, it may be broken and removed with a large auger having scarifying teeth.

Such large holes afford a superior means for inspecting the spacing and tightness of joints, seams, and fissures; and the existence and nature of soft layers not recoverable in small-diameter core-boring work. These holes can be drilled only where it is possible, by pumping or grouting, to control the water entering the hole.

In permeable or open rock where the flow is too free to be controlled by pumping, water may be controlled by preliminary grouting, through holes drilled either outside of or within the circumference of the proposed

large-diameter hole. Inspection of large-diameter holes in pregrouted rock also affords valuable information as to the effectiveness of the grouting.

AN ENGINEER ABOUT TO INSPECT A 30-IN. CORE BORING, TYGART DAM SITE, W.VA.

OTHER METHODS OF EXPLORATION

In materials not amenable to core work, some type of churn-drilling or wash-boring is generally employed. These methods serve to determine the depth to the rock surface, the depth of weathering, or the position of hard rock layers in shale too soft to core. The samples recovered by settling the material washed from the holes serve to identify the general nature of the material, but are of little use as a basis for physical measurements or mechanical analysis because the colloidal and other fine suspended matter is usually lost. Various methods have been devised for securing representative samples of non-coring materials by driving into them cylinders designed to retain the sample on withdrawal.

Geophysical methods have a useful application in certain phases of dam-site exploration, principally in determining the thickness of the overburden. They are especially useful in preliminary examinations of tentative dam sites, as the equipment is easily transported and the field work can be done rapidly.

When the overburden is stratified and contains layers of varying electrical and physical properties, so that the correct interpretation of geophysical data becomes difficult, the data should be checked against a known geological section such as a bore hole. However, this may not be necessary when the overburden is fairly homogeneous and the only sharp discontinuity in electrical or physical properties occurs at the rock surface.

Geophysical methods have a possible application in discovering caverns and solution channels in limestone. At the Dix Dam in Kentucky, submarine acoustic methods, which may be properly included in the general field of geophysics, have been applied successfully in locating leaks in cavernous limestone beneath the reservoir.

It is often advantageous to record the results of drill-hole exploration on three-dimensional models such as peg models, where each drill hole is represented by a rod on which the log is indicated by colored paints. Other useful forms are transparent celluloid models showing the geological conditions in plans and sections, and relief models showing the surface topography and geology.

DAM SITES IN IGNEOUS AND METAMORPHIC ROCKS

Rocks of the metamorphic or igneous type are as strong as or stronger than concrete, and their bearing strength is adequate except where they are weakened by weathering or by structural features such as faults or shear zones. Among them are granite, monzonite, syenite, diorite, diabase, gabbro, and other intrusive igneous rocks; thick masses of volcanic rocks ordinarily termed trap rock; thoroughly cemented volcanic conglomerates and breccias; gneiss, schist, slate, marble, and quartzite.

Elastic properties of the rock and existing strain conditions assume importance in proportion to the height of the dam and the magnitude of the stresses imparted by it to the foundation and abutments. All foundation and abutment rocks yield elastically to some degree, and this deformation should be anticipated as a basis for proper design, particularly in the foundations for high gravity dams and the abutments of arch dams. This involves the testing of representative samples in the laboratory and the measuring of resident strain in the rock in place in suitable tunnels in the foundation and abutments.

In igneous and metamorphic rock, the boundary between masonry and rock is almost never a plane surface. Consequently resistance to sliding depends upon the shearing strength of the concrete and of the foundation and abutment rocks. It therefore becomes important to determine the shearing strength of the foundation rocks in directions parallel to the shear which would be involved in the sliding of the structure.

Openings in rocks of this class which might permit leakage through foundations or abutments are open joints, fractures or fissures, shear zones, and faults. With the exception of marble, the rocks of this class are insoluble, and open solution channels or cavities do not occur.

In rocks of this type the joints may be sufficiently open to require grouting near the surface. These may consist of fractures and zones of shear resulting from earth movements. Shear zones involving undesirable thicknesses of broken and decayed rock may require the excavation of unacceptable material and replacement with concrete. Exploration should be sufficiently complete to disclose any of these undesirable structural features before foundations are prepared, so that proper allowances can be provided in drawing up plans and making estimates.

Faults call for careful consideration, since they constitute planes of weakness on which movement has occurred and may occur again, and if they cross the line of the structure they present possible avenues of leakage. It is desirable, if possible, to so locate the dam that it is not crossed by faults. In a faulted region known to be seismically active, it is advisable to locate the dam entirely within a solid block between known fault planes, in the expectation that future earth movements will make use of existing faults. In regions that are known to have been free from fault movements and seismically undisturbed for long periods, the existence of faults in foundations or abutments involves only consideration of their effects on watertightness and stability.

Preliminary exploration should be adequate to determine the amount of excavation involved in the preparation of foundations. This includes the removal of disintegrated and decomposed rock; of loose unweathered rock in which the joints, cleavage planes, and other

planes of weakness have been unduly opened by surface agencies; and of alluvial fill.

No special treatment is required to insure bond between masonry and rock of this class. Care should be taken to keep the use of explosives to a minimum in order to avoid opening joints and partings in otherwise sound rock.

All igneous and metamorphic rocks are susceptible to the destructive action of surface weathering agencies, both mechanical and chemical. The irregular depth to which decay penetrates results in a very irregular boundary between fresh and weathered rock, with deep reentrants along joints and shear zones. This condition may complicate the problem and increase the cost of preparing abutments.

In some instances, decay in the upper part of the abutments extends below the top of the dam, making it necessary to consider the stability and watertightness of this weathered material. In general, it contains a large element of clay which tends to reduce the permeability. The residual material from acid feldspathic rocks and igneous rocks of the granitic type may be porous and have a permeability comparable to that of medium-grain sand, and consequently may require some type of cut-off wall or special treatment of the upstream surfaces. This material, however, is homogeneous and does not have open zones in which leakage can concentrate.

DAM SITES IN SANDSTONE

Sandstone varies in composition and appearance from the light-colored quartz types to the darker-colored varieties containing varying amounts of feldspars and ferromagnesian minerals. These darker varieties are called arkose when the feldspar predominates and sometimes greywacke when the ferromagnesian minerals are prominent. All sandstones have been formed by the consolidation of sand deposits and the infiltration of cementing materials, principally carbonates and silica. By complete cementation with silica they become quartzites.

The strength of sandstone depends on the completeness of cementation and the nature of the cementing material, and varies from well-cemented rock much stronger than concrete to weak, friable, poorly cemented material. It is important therefore to determine the physical properties experimentally. In structures involving more than moderate load concentrations, investigation of the elastic properties also becomes important. As a foundation rock, even poorly cemented sandstone is not susceptible to plastic deformation, in contrast to many shales.

Resistance to sliding is essentially a question of the shearing strength of the sandstone. As a whole, sandstones have high coefficients of internal friction which give them high shearing strength when restrained under load. With sandstones, interstratified beds of clay or shale are frequently found, and these, if at shallow depths, may constitute potential sliding surfaces. Exploration should investigate this possibility so that proper measures can be taken. These may involve excavation to a depth below the objectionable layer.

Openings in sandstone which may permit the flow of water beneath or around a structure are of the same types as those previously discussed under igneous and metamorphic rocks. In addition, it is possible for water to pass through the intergranular pores of the rock itself. The permeability of sandstone varies with the grain size and the completeness of cementation, and may be sufficient to involve undesirable leakage. Cement grouting has not proved successful in overcoming this difficulty. The application of soluble silicate cements has been tried abroad, but the writer is not familiar with the methods or results obtained.

Preparation of foundations involves the excavation of any overlying alluvial materials and of all unsound rock. No special treatment is required to insure good bond with the concrete. Sandstone, with the exception of shaley or argillaceous varieties, is not subject to rapid surface deterioration on exposure. Quartz sandstone weathers to a residual sand, which grades downward through intermediate, soft, partially weathered phases to the original rock beneath. This residual sand is porous and permeable, and in cases where the upper part of a dam structure is tied into such weathered material, proper measures for cutting off or reducing leakage must be taken. The feldspathic and ferromagnesian sandstones—arkose and greywacke—weather to an open-textured permeable material containing considerable clay, which gives the material more stability and less permeability.

DAM SITES IN LIMESTONE

The term "limestone" is used here to include both limestone and dolomite, which are essentially the same so far as engineering problems are concerned. Limestones vary from dense, strong, finely crystalline rock to relatively weak, soft, marly or chalky rock.

Ripple Corrugations in Thin Bedded Sandstone Foundation Increase Resistance to Sliding
Core Drilled at Bluestone Dam Site, W.Va.

Exploration of Folded Limestone at Chickamauga Dam Site on the Tennessee River
This Type of Rock Must Be Carefully Investigated

Most limestones are as strong as or stronger than concrete. Limestones of the poorly lithified type are obviously weak, and tests of physical properties should be made where there is any question of adequacy. Limestone is a soluble rock, and is characterized by solution channels and caverns. Foundation and abutment rock appearing sound at the surface may have concealed solution openings. Exploration should be extensive enough to disclose the existence of any such openings in the foundation or abutments close enough to the surface to affect the bearing strength of the foundation.

THIS POROUS LIMESTONE STRATUM PERMITS EXCESSIVE LEAKAGE FROM A RESERVOIR

There is no reason for apprehension over the possibility of damage caused by the solution of foundation or abutment rocks, as the rate of solution of limestone, though rapid as a geologic process, is too slow to constitute a threat. The concrete is more vulnerable than the limestone.

Resistance to sliding involves the shearing strength of limestone. If thin-bedded, with well-developed bedding partings, a possibility of slipping on such partings may exist. This should be guarded against, if necessary, by suitable keying of the structure into the foundation rock. Limestone may have thin interstratified shale or clay layers along which there is low resistance to shear. Exploration, particularly with large-diameter core borings, should disclose this condition.

Because of the soluble nature of limestone and the consequent likelihood that it contains solution channels and caverns, unusual care is necessary in the exploration of foundations and abutments and also of the reservoir rim. A variety of factors determine the location, extent, shape, size, and depth of these underground openings. In some instances, certain strata are much more soluble than others, and a study of the limestone in the general vicinity of the dam site may indicate the bed or beds requiring particular attention. Solution channels and cavities may be localized by very gentle regional folding which has opened joints and invited solution along the anticlinal arches, in contrast to the unopened joints of the synclinal troughs. This factor may determine the location of a feasible site in a cavernous formation.

Solution channels in general may be looked upon as an underground drainage system, and the divides in this system frequently coincide approximately with the divides in the surface topography. Water entering openings in the limestone finds outlets along the river valleys. In areas which have experienced regional depression, solution channels developed prior to such depression may be found below the level of present valley bottoms. A past history of lower water-table conditions may also have developed deep solution channels.

In addition, limestone foundations and abutments may contain open joints, fractures, fissures, shear zones, or faults. Their consequences and treatment are essentially the same as in other types of hard rock.

The establishment of a watertight cutoff through cavernous limestone presents difficulties in proportion to the size and extent of the solution openings. It is almost impossible to explore abutments, foundation, and reservoir rim in such detail as to discover all possible solution channels. Two alternative courses of procedure may be followed: (1) Permit the reservoir to fill, and if undesirable leakage occurs, draw down the reservoir and apply remedial measures; (2) attempt to establish a grout cutoff through the abutments where leakage is suspected before the reservoir is filled. The former method has the advantage of saving unnecessary grouting and of concentrating the effort to stop leakage at specific points. The latter prevents the appearance of leaks which might be disturbing to the public and lead to ungrounded fears.

Cement-sand grouting has not proved universally effective in closing openings in cavernous limestone, particularly if the openings are a few feet wide or wider. Grouting with hot asphalt has proved effective in some instances and holds much promise of usefulness, since the asphalt solidifies on cooling and builds up temporary barriers against which cement grouting may later be placed. Grouting with clay has been thoroughly successful in the cavernous limestone of the rim of Madden Dam Reservoir, Panama Canal Zone.

Solution channels may be open or partially filled with clay. Clay-filled channels may permit the passage of only a small amount of water when the reservoir is first filled, but the flow may increase as the clay is washed from the openings. This may give the erroneous impression that the openings are being rapidly enlarged through the solution of the rock, and may require a program of leak-stopping extending over a considerable period after the reservoir is filled.

Preparation of foundations involves excavation of all alluvial deposits that may cover the foundation, and removal of unsound rock. It may also be necessary to remove undesirably thin rock layers over solution openings and to clean these openings before they are filled with concrete. Limestone requires no special treatment to insure good bond with concrete, and its surface does not deteriorate on exposure to the air. If shale beds are interstratified with the limestone, they may require special precautions and special treatment.

The surface weathering of limestone, dolomite, and marble produces a residual accumulation of relatively insoluble impurities, consisting of clay, chert, and iron oxide. These residual clays are in general impervious to water, but in some instances erosive action has washed away the clay, leaving a highly porous accumulation of chert and "iron-stone" fragments. The boundary between the rock and the residual mantle is generally very irregular, with ridges and pinnacles of rock and deep clay pockets.

This concludes discussion of the physical properties of igneous and metamorphic rocks, sandstone, and limestone, which have engineering significance in the selection of dam sites. A discussion of corresponding qualities in shale and earth will be reserved for a later article.

Recent Advances in Hydrographic Surveying

Including Use of the Taut-Wire Apparatus, Sono-Radio Buoy, and Fathometer

By Paul A. Smith

Associate Member American Society of Civil Engineers
Lieutenant, U. S. Coast and Geodetic Survey, Washington, D.C.

Although many new devices have been added to ships' equipment in latter years, none can ever take the place of the nautical chart as an aid to navigation. A number of recent developments have contributed to the economy and accuracy of chart-making. The taut-wire apparatus, or "sea-going tape," permits precise measurements to be made at sea in comparatively shoal water. By automatically relaying the sounds of a surveying vessel's bombs transmitted to them through the intervening water, sono-radio buoys provide an effective means for position-finding. Modern sounding work is done with two types of fathometers, designed for use in deep and shallow water, respectively. In the accompanying article, Lieutenant Smith describes these and other new departures in hydrographic surveying work.

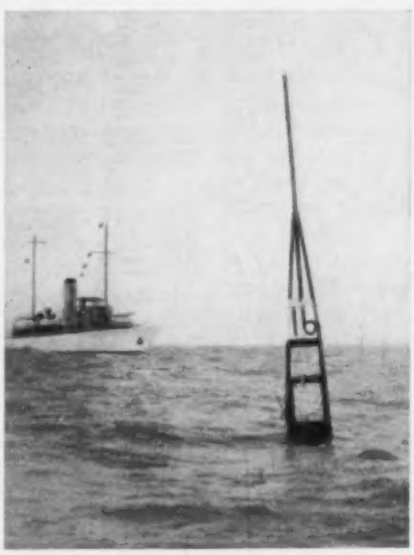
The continuous stream of vessels to and from the important ports of the world provides intercourse between nations and gives to man a means of exchange for the products of his handiwork. His general prosperity and comfort are promoted by international exchange of the commodities produced by his skill and labor from the natural resources of his individual environs. The successful blockade of enemy ports is a major strategy in war, and "sanctions" is a popular press word in these times of international thought.

If all the charts of important harbors suddenly were to be destroyed, and if all existing information from which the charts could be reconstructed were obliterated, these ports would be closed to commerce almost as completely as though a powerful enemy fleet had thrown a blockade about each. Charts, therefore, play an important part in the economic welfare of nations. They raise the blockades established by hidden rocks and shoals and reveal the safe channels; they open the ports of the world to commerce.

Many valuable and important aids to navigation have been devised within the last generation, even within the last decade; but without the aid of a nautical chart no instrument or device can be relied upon in piloting a modern ocean liner safely and without delay into the port of her destination. Lighthouses, buoys, and fog signals, vital as they are to shipping, would be useless without charts showing their relations to one another, to the submarine features of the ocean, and to the topography of the land. Radio compasses and echo sounders would, as now, give bearings and reliable depths, but such bearings and soundings would have little meaning without a picture in the form of a chart to enable the navigator to reckon his position and locate it with reference to man-made aids and natural hazards.

Not so many years ago a nautical chart was considered adequate if it delineated the shore line, showing only the dangerous rocks and shoals along the main routes, a few scattered soundings, and the outstanding landmarks from which mariners could fix their positions when within sight of land. Much space was devoted to elaborate displays of the engraving art, representing the cartographer's idea of what the intrepid sailors of the seven seas might expect to encounter. In those days a landfall was only attempted in daylight and good weather.

Again, there is a great difference between handling a 300-ton windjammer rolling along at a maximum speed of 10 knots, and a 25,000-ton passenger liner cruising at 25 knots, making port on a strict schedule. Modern high-speed ships use, wherever available, accurately charted and characteristic submarine features for fixing positions. In order to fix a position accurately by this method, it is necessary, of course, that the submarine features be located with adequate precision. The Coast and Geodetic Survey of the U. S. Department of Commerce is responsible for the nautical charts of the coasts of the United States and its possessions.



A Sono-Radio Buoy, with the U. S. Coast and Geodetic Survey Ship "Lydonia" in the Background

This Buoy Takes the Place of Station Ships by Receiving the Underwater Sounds from Small Bombs and Relaying Them as Radio Signals

Recharting New York Harbor Approaches

A survey of immediate interest is the one of the approaches to New York harbor conducted during the summer of 1936 by the Coast and Geodetic Survey. The area covered and the methods used are indicated in Fig. 1. The chart of this important part of our coastal waters previously in use had been based on surveys made as far back as 1882. Needless to say, it was inadequate for modern ocean commerce equipped with echo sounding apparatus. The methods and developments of this survey are of engineering interest since it not only makes an important contribution to the shipping world but, in addition, has revealed some unsuspected and intricate submarine topography beyond the coastal shelves.

The nature of this topography indicates erosional features in the majority of cases, and this discovery undoubtedly will change many cherished geological theories of the origin of the continental shelves. Combined with the increasing use of echo sounding by merchant vessels, it may change the existing form of the nautical chart. Already it has stimulated numerous scientific organizations to investigate the ocean bottom, and much valuable work has been done, yielding some amazing discoveries. Outstanding among investigators are H. C. Stetson, Woods Hole Oceanographic Institution; C. S. Piggott, Geophysical Laboratory,

Carnegie Institution of Washington, D.C.; and Maurice Ewing, Geological Society of America.

Surveying operations of this kind combine many of the older established methods of surveying with some of the most recent discoveries in the electrical and physical sciences. The practical application of the latter to the everyday needs of the hydrographer demands simplification of the apparatus and more rugged mechanical parts than are usual in the laboratory or on shore.

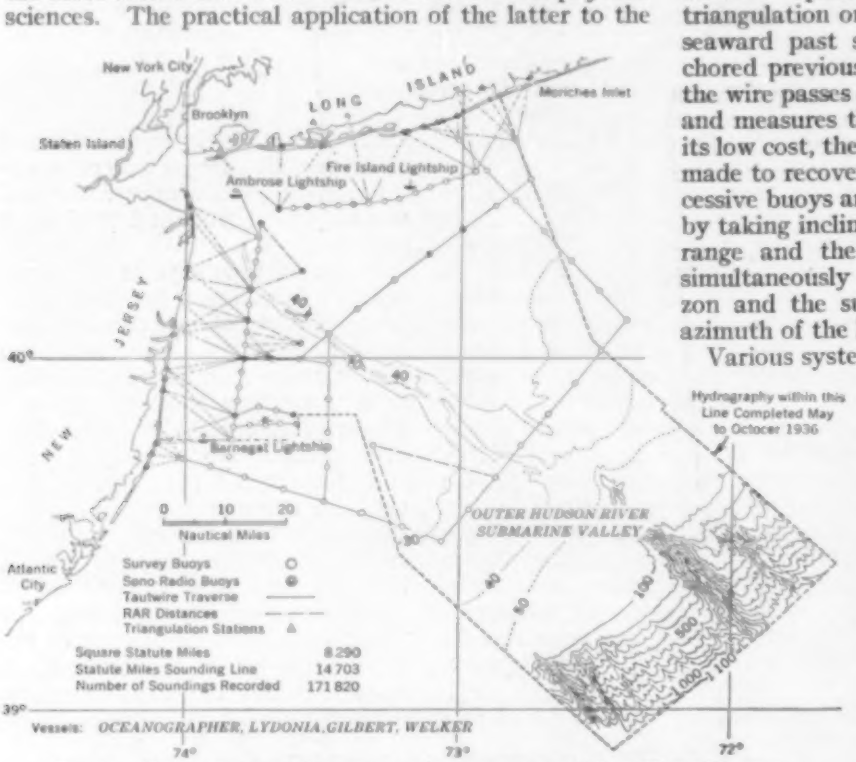


FIG. 1. HYDROGRAPHIC SURVEY OF APPROACHES TO NEW YORK HARBOR Made During the Summer of 1936 by the U. S. Coast and Geodetic Survey

A novel application of ordinary land traverse methods has marked a long step forward in economy and accuracy of control for hydrographic surveys in regions similar to our Atlantic and Gulf coastal shelves. The most practicable method of establishing horizontal control for offshore surveys in relatively shoal water is through a system of floating signals, which carry targets visible at distances of from 6 to 8 miles. These signal buoys have been used by hydrographic surveyors for many years. Various methods of obtaining accurate positions for them have been tried. The buoys are anchored with as short a scope as is consistent with the depth of water and the weather conditions to be encountered. They are spaced over the area to be surveyed so as to provide a visual "fix" by sextants, or a radio acoustic position from the surveying vessel, in all parts of the work. Until recently, such buoys were located by dead-reckoning runs with the surveying vessel, or by establishing successive rows of the buoys parallel to shore and carrying the control from one row to the next by the conventional three-point fix method or other forms of sextant triangulation.

TAPE MEASUREMENTS AT SEA

Several years ago the taut-wire apparatus for measuring distances at sea in comparatively shoal water was devised in England and used by the Hydrographic Office of the Admiralty in hydrographic surveying. It was adopted by the U. S. Coast and Geodetic Survey for work on the coastal shelves about five years ago. This device has been dubbed "a sea-going tape" by a writer of popular scientific articles. The equipment is mounted on the deck of the surveying vessel.

One end of the wire is anchored inshore or near a buoy, where the position can be determined with reference to triangulation on shore. As the surveying vessel steams seaward past successive buoys, which have been anchored previously in the approximate positions desired, the wire passes out over the accurately calibrated sheave and measures the distances between them. Because of its low cost, the wire is used only once, and no attempt is made to recover it. The surveying ship proceeds; successive buoys are ranged up; and azimuths are observed by taking inclined angles between the adjacent buoys on range and the sun. The inclined angle is observed simultaneously with a vertical angle between the horizon and the sun, and a simple calculation yields the azimuth of the line between the buoys.

Various systems of traverse are selected to fit the project. The traverse shown in Fig. 1 was 155 statute miles in length between the position off Fire Island, L.I., and the position off Barnegat, N.J. The closing error between these two controlled points was about 0.7 m per mile. This traverse was run by Commander H. A. Seran, U.S.C. and G.S., M. Am. Soc. C.E., commanding officer of the ship *Oceanographer*, to provide the control for the offshore work carried on by that vessel. A similar system of buoy control is used by Lieut.-Commander F. S. Borden, U.S.C. and G.S., Assoc. M. Am. Soc. C.E., commanding officer of the ship *Hydrographer*, operating in the Gulf of Mexico.

In detailed hydrography, the position of the vessel is controlled either by visual fix position directly on the buoys, or through radio acoustic ranging from station ships or sono-radio buoys anchored near the position buoys. Soundings are taken by fathometers, and verified by occasional wire or hand lead soundings.

FIXING POSITION BY RADIO ACOUSTIC RANGING

Radio acoustic ranging, which is a method of position-finding utilizing the travel time of sound in sea water, is represented graphically in Fig. 2. The apparent horizontal velocity of sound must of course be

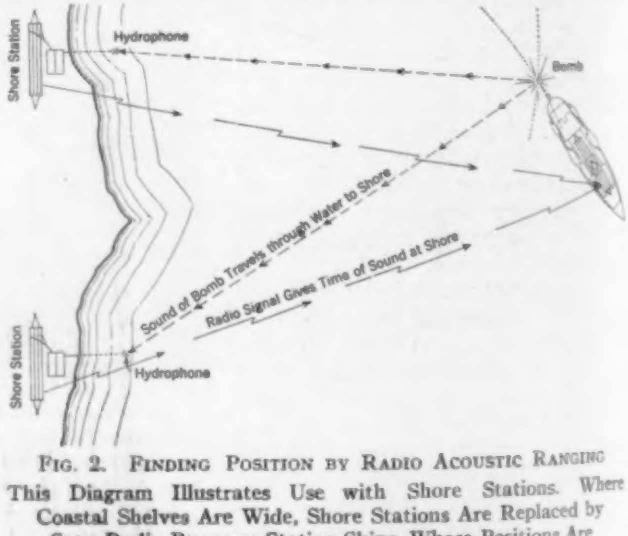


FIG. 2. FINDING POSITION BY RADIO ACOUSTIC RANGING
This Diagram Illustrates Use with Shore Stations. Where Coastal Shelves Are Wide, Shore Stations Are Replaced by Sono-Radio Buoys or Station Ships, Whose Positions Are Determined by Triangulation Control from Shore

known. In some regions it has been possible to use the velocity as determined from theoretical tables for the bottom temperatures and salinities, but in practically all projects where the theoretical velocity is used, it is verified by actual measurement. Where the temperature gradient of the water relative to the depth is irregular, complicating conditions sometimes are found which require special treatment of observations. In Fig. 3 is a diagrammatic sketch of the horizontal travel of sound in deep sea water. The velocity gradient, which is indicated by the shaded part at the left of the sketch, is a function of the temperature, salinity, and pressure.

The information shown in Fig. 3 is corroborated by many oscillograph records made from bombs fired in depths up to 850 fathoms in recent experiments off the California coast by Lieut.-Commander O. W. Swainson, U.S.C. and G.S., Assoc. M. Am. Soc. C.E., commanding officer of the ship *Pioneer*, in cooperation with Capt. F. H. Hardy, U.S.C. and G.S., M. Am. Soc. C.E., commanding officer of the ship *Guide*. Formulas for approximating the apparent horizontal velocity from surface temperatures and salinities were devised and given in Lieut.-Commander Swainson's official report on this work. These experiments explained many of the small discrepancies which have occurred from time to time during the use of this method, and established facts which should further increase its accuracy.

Where submarine topography is such that deep water is found near the beach, it has been possible to place the

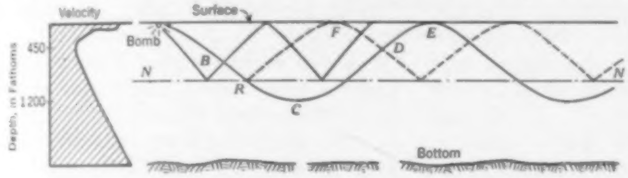
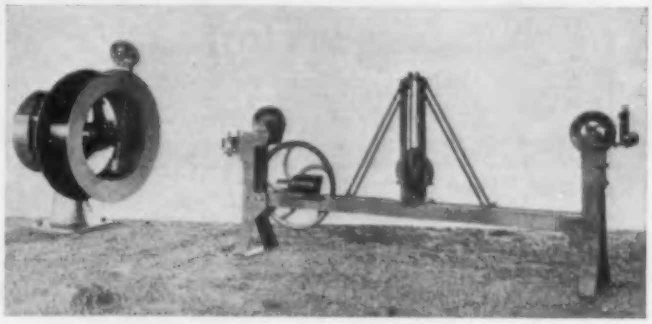


Fig. 3. Propagation of Sound in Deep Sea Water
Under the Conditions Shown, the Sound Ray Follows the Line *B-C-E*. In Shallow Water, with the Bottom at *N-N*, the Dotted Line *B-R-F-D* Is Followed. The Velocity Gradient Is Shown on the Shaded Area at the Left

hydrophones at short distances offshore and connect them to radio acoustic stations on land through submarine cable. This is done on the Pacific coast of the United States and in Alaska, where the hydrophones can be placed so as to receive the underwater sounds without obstruction from off-lying shoals or banks. On the Atlantic and Gulf coasts, where the coastal shelves extend many miles out to sea and the water is comparatively shallow, it has been necessary to station the hydrophones at some distance from shore and in water more than 15 fathoms in depth in order to avoid the attenuation of the underwater sound experienced under shoal conditions. At first, the necessary equipment was installed on small vessels which were anchored offshore as station ships, but during the past summer an automatic sono-radio buoy, developed in the laboratory of the Coast and Geodetic Survey, has been used successfully.

This small buoy was designed to take the place of the station ships heretofore used to receive the underwater sounds from small bombs exploded by the surveying ship, and to relay them back as radio signals. For economic reasons, the usual practice has been to utilize for this purpose vessels as small as is consistent with safety of personnel in storms. These small vessels always have been a source of worry to the officer in charge of the survey, and the necessity of their seeking refuge in safe harbors has often curtailed the amount of work accomplished when the more seaworthy surveying vessel could have continued hydrographic work. The preliminary buoys in use at present are constructed of two gasoline drums. One of these contains an audio amplifier, radio transmitter, and batteries, while the other is used for buoyancy alone. This little floating



Taut-Wire Apparatus for Measuring Distances at Sea
The Wire Passes from the Drum at the Left Over the Flyer on the Drum and Through the Idling Sheaves on the Mechanism at the Right. The Large Sheave Is the Recording Device

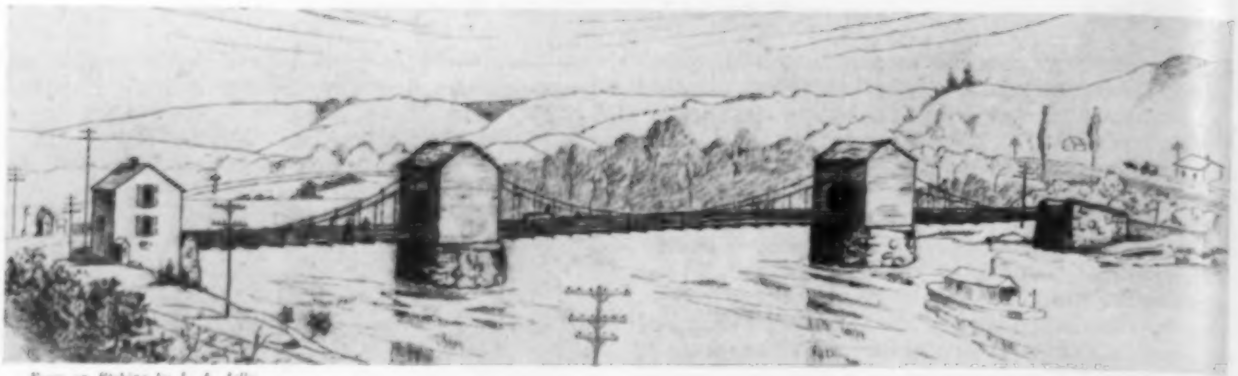
audio and radio station, insignificant as it appears in the photograph, has been audible at my home in Arlington, Va., giving bomb returns to the surveying vessel during operations off the approaches to New York harbor.

The buoys also eliminate the danger of collision between shipping in the vicinity and anchored station ships. This hazard was encountered during the survey of Georges Bank, 1930–1932, when the station ships were forced to anchor on or near the North Atlantic steamship lanes during the prevailing foggy weather. From personal experience, I might say that it is a disconcerting experience to be at anchor on station and hear one of the fast liners come booming along in a fog at a "reduced" speed of about 20 knots. According to international rules, being at anchor, we could do no more than ring the ship's bell at frequent intervals. (Several bells were broken by enthusiastic surveyors.)

Modern Methods of Sounding

As mentioned, sounding is done with fathometers. The usual commercial form of this instrument, with minor modifications made by the Survey to increase its accuracy, is used in deep water, that is, in depths over about 30 fathoms (180 ft). Another precise type of fathometer has been developed by Dr. Herbert Grove Dorsey, principal electrical engineer of the Coast and Geodetic Survey, for special surveying needs in shoal water. This device disclosed some interesting facts when its readings were compared with hand lead soundings taken from ships both under way and stopped. It gives 20 soundings per second at full speed and can be read to within about 0.25 ft. A frequency of about 17,000 cycles, inaudible to most human ears, is used in the Dorsey fathometer in place of the usual 1,000-cycle note in the fathometer for deep-water sounding.

These engineering and scientific developments adapted to surveying needs have enabled the Coast and Geodetic Survey to make hydrographic surveys at about half the unit cost prevailing with methods used in the past. Furthermore, as was pointed out earlier, the resulting accuracy has permitted thorough hydrographic development of offshore areas out of sight of land. In hydrographic surveying, as in many other branches of engineering, development of the electrical and physical sciences is changing many of the older procedures contributing towards economy and extension of knowledge in the earth sciences of geology and oceanography.



THE OLD CHAIN BRIDGE AT LEHIGH GAP, PA., 1826–1933

An Early American Suspension Span

Description and Brief Historical Account of a Chain Bridge of 1826

By W. H. BOYER
and IRVING A. JELLY
RESPECTIVELY CHIEF ACCOUNTANT AND ENGINEERING DRAFTSMAN, THE NEW JERSEY ZINC COMPANY, PALMERTON, PA.

AS the mighty suspension bridge over the Golden Gate nears completion, it is interesting to turn back the pages of engineering history for a moment, to the days of its modest forebear, the old chain bridge of the early eighteen hundreds. Typical of this design was the span over the Lehigh River at Lehigh Gap, Pa. It was built in 1826, and carried traffic for more than a century, finally yielding place to a concrete structure in 1933. It was probably the last surviving specimen of the type patented in 1808 by James Finley, pioneer American bridge builder. The etching, as well as the other drawings, was prepared by Mr. Jelly. This article is sponsored by the Joint Division on the History of Engineering now being formed by representatives of the Founder Societies.

AS an example of early American bridge architecture, the chain suspension span built across the Lehigh River at Lehigh Gap, Pa., in 1826 is of especial interest. It was built under one of the first patents for bridge design issued in the United States, yet met the demands of modern traffic until 1933.

The Lehigh bridge has a span of 160 ft between piers, and the end spans of 80 ft each brought the total length to 320 ft. The supporting chains were made up of hand-wrought links about 8 ft in length, supported over the piers on timber framing and anchored at the ends in the masonry of the abutments (Figs. 1 and 3). The suspender bars, one to each link of the supporting chains, were also of wrought iron, and were provided with eyes at their lower ends to accommodate the timbers of the lower, or transverse, tier of joists (Fig. 2). The longitudinal joists, or stringers, were 6 by 8-in. timber, and carried a flooring of 3-in. oak plank.

Most of the design details are indicated in the figures previously referred to. Particular attention should be called to the provision for carrying the chains over the saddles and for attaching the suspenders. The detail of the link at midspan suggests the method of erection; half of each main span chain must have been attached first to the forgings on the saddles, after which the two halves were drawn together and connected, in place, at the center. The two chains were adjusted to equal length by means of a wedge inserted in one of them between the short center link and the pin. The structure was a hand-wrought job throughout—there were no threads or turned work, or delicate, intricate design.

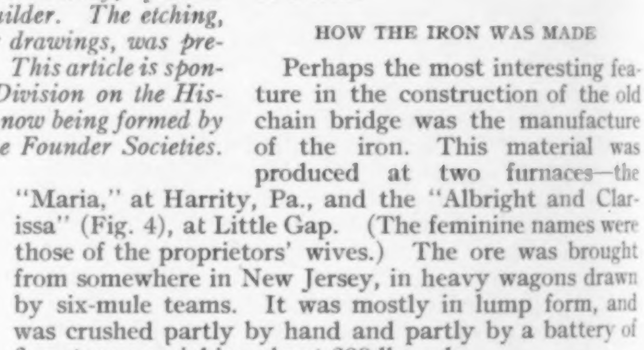
The estimated weight of materials in a half span of 80 ft is 15.6 tons (lumber 13.8 tons, and iron 1.8 tons). If to this we add a 10-lb snow load, we have a total dead weight for the half span of 22.1 tons. The maximum tension in each cable occurs at the support and, for dead load only, would amount to 53,500 lb. This is equivalent to a unit stress of 11,900 lb per sq in. Assuming a permissible working stress of 16,000 lb, the cables could carry a uniform live load of 190 lb per lin ft in addition to the snow load.

As for concentrated loads, each pair of suspenders could support a weight of about 22 tons in addition to the dead load of the roadway and snow. Each of the 6 by 8-in. floor beams, with 7-ft span, was able to carry a concentrated load of 3 tons.

HOW THE IRON WAS MADE

Perhaps the most interesting feature in the construction of the old chain bridge was the manufacture of the iron. This material was produced at two furnaces—the "Maria," at Harrity, Pa., and the "Albright and Clarissa" (Fig. 4), at Little Gap. (The feminine names were those of the proprietors' wives.) The ore was brought from somewhere in New Jersey, in heavy wagons drawn by six-mule teams. It was mostly in lump form, and was crushed partly by hand and partly by a battery of five stamps weighing about 200 lb each.

These stamps, like all the other mechanical devices at



HAND-FORGED LINKS FROM OLD CHAIN BRIDGE PLACED IN MONUMENT AT PALMERTON, PA., AFTER 107 YEARS OF SERVICE

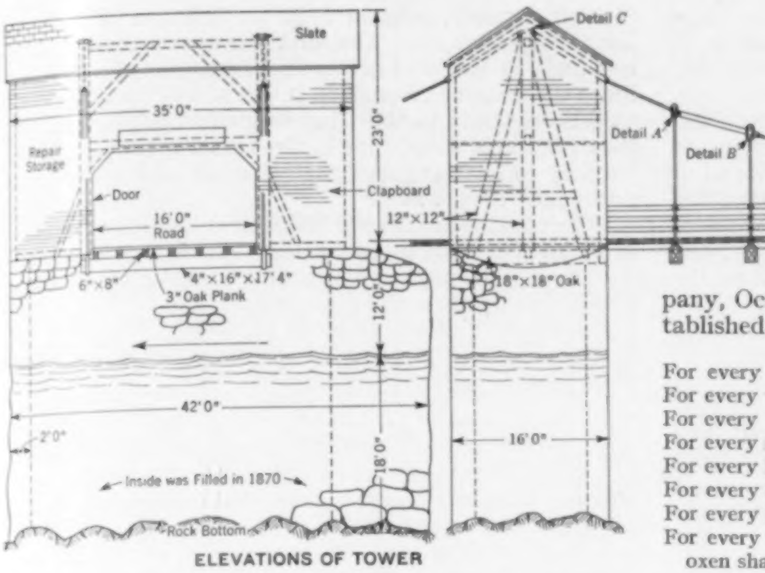


Fig. 1. Abutment and Pier of the Chain Bridge at Lehigh Gap, Pa.

the furnace, were operated by water power; the sketch makes clear the method. Each stamp was suspended from one end of a horizontal rocker arm, which was pivoted at the center and rested at the other end against a rotating cam. The cams and camshaft were a single, solid piece of oak, shaped and planed by hand. The diameter of the shaft itself was 1 ft. The ore to be crushed was placed on heavy, perforated iron plates, through which it fell when it had been reduced to pieces of the proper size.

There were five furnaces, each about 6 ft square and 5 ft high. The casing was made of stone, with lime and sand mortar, and the lining was fire-brick made of native clay and sand. The base was also of clay and sand, pounded together firmly and tapered towards the center so that the iron, when smelted, would flow together and form a single mass. Each furnace had a single tuyère, to which air was supplied by a large bellows.

In making up a charge, a thick layer of charcoal was first placed in a furnace, packed down tightly, and lit. Air was applied, and as soon as the fire had reached the proper temperature, as judged by the fireman, a layer of crushed ore was put upon it and left undisturbed until the fire had burned out. The clinker and refuse were then raked away and the iron, which had run together at the bottom, was removed with large tongs and partly shaped to size. Each furnace could be charged and drawn twice during a shift (3 a.m. to 3 p.m.), and the producing capacity for the complete installation averaged about 5 net tons per day.

About half the time the furnaces were used for reheating the partly finished iron, so that it could be worked on the anvils. The hammers, weighing about 500 lb each, were operated by wooden camshafts similar to the one driving the stamps.

This was a slow process of production, but the iron was of high quality. The links in use in the bridge for more than 100 years were never painted, yet show no signs of rust. Some of the hammer-marks are still visible, and a peculiar leaf lamination can be seen when the links are closely scrutinized.

History of the Bridge

The Lehigh bridge was built for the "Lehigh Water Gap Bridge Company" by one Jacob Blumer, at that time the only engineer in the Lehigh Valley. For his services, according to the records of the company, he was paid $233.75. As for materials, the iron, completely fabricated, was purchased for 980.19^1/_2$, while the timber seems to have been obtained for nothing from the surrounding forests. There are no records of the cost of working it into shape, or of constructing the piers, or of erecting the superstructure.

At a meeting of the managers of the company, October 26, 1826, the following toll rates were established:

For every coach or pleasure carriage, with four horses	31$^1/_4$¢
For every wagon loaded and with four horses	25¢
For every sulky or sled with one or two horses	6$^1/_2$¢
For every single horse and rider	6$^1/_2$¢
For every horse or mule led	4¢
For every foot passenger, sheep, or swine	1¢
For every head of horned cattle	2¢
For every wagon drawn by oxen, wholly or in part, two oxen shall be intended as equal to one horse.	

Funeral processions, doctors, ministers, and people on their way to church were exempted from toll charges. These privileges remained until 1900, when they were canceled by the board of directors.

The carrying capacity of the bridge was based on livestock weight, as shown by a sign on one of the abutments:

$10 Fine for Riding or Driving Across This Bridge Faster Than on a Walk
$10 Fine for Driving More Than 30 Head of Horned Cattle at Any One Time Over This Bridge

In recent years few cattle were driven across the bridge, but hundreds of automobiles took their place, and put the structure to a good test of strength. During the War, army truck trains frequently used this crossing, and one particular truck with a net lading of 12 tons crossed without any indication that the bridge was overloaded.

On three different occasions the bridge suffered considerable damage from flood. In 1841 a flood broke one of the chains and damaged one abutment to such an extent that the company did not feel itself financially able to make the repairs. One of the stockholders thereupon financed the work, under an arrangement whereby he

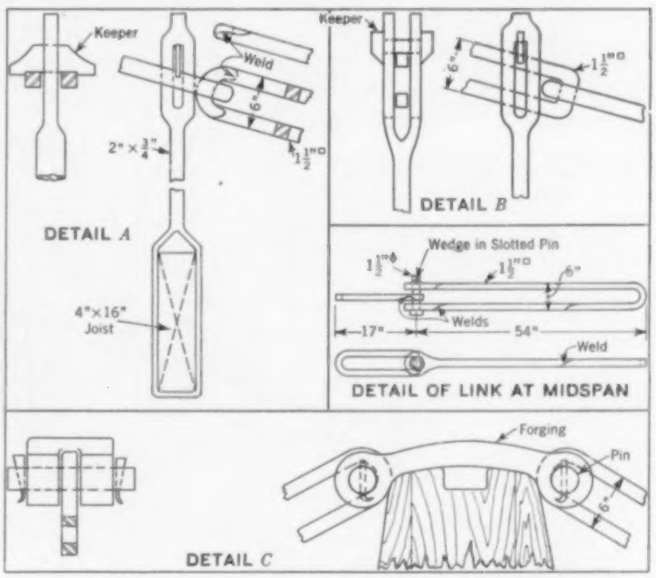


Fig. 2. Details of Design of Chains and Suspenders

would be repaid when the company could afford it. The directors must have been cautious indeed to hesitate in financing the work themselves, for it is a matter of record that the stockholder was paid back in short order.

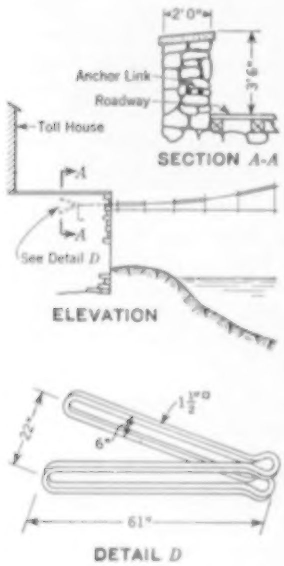


FIG. 3. ANCHORAGE OF A SUSPENDER CHAIN

In 1857 an ice freshet damaged the west abutment to some extent, and moved it almost a foot out of position. Five years later a large dam at White Haven broke, and the waters pouring down the valley swept almost everything before them. A canal boat, torn loose from its moorings, struck the bridge and broke one of the chains. Again repairs were made and traffic was renewed. In 1902, the old bridge was again tested by a flood in which the waters rose to the floor planks, but there was no damage to either superstructure or foundations.

A fire in 1926 destroyed most of the wood work, especially in the pier houses, and exposed the A-frames holding the chains. This inconvenience, and the risk of its repetition, forced state officials to consider abandoning the old bridge, and in 1933 it was replaced by a modern concrete and steel structure a short distance upstream.

When the chain bridge was razed, there was a wild scramble for its links and suspenders, and they were allotted to institutions of learning and to friends and relatives of the owners. Palmerton, the nearest town, has used some of the links in a memorial.

After the demolition, one of the authors made an examination of the foundations and the anchorage. The mortar was found to have been made of lime mixed with screened coal; the latter material had probably been scooped from the river bed, where it had collected as it fell from passing barges. This mortar is still firm and shows no sign of disintegration.

OTHER OLD SUSPENSION BRIDGES

How does the chain bridge fit into the history of bridge building? Early European travelers in China, it is said, found several suspension bridges made of iron chains. At least one of them was so ancient that the inhabitants were ignorant of the date of its erection, and attributed it to a fabulous builder. According to Charles Stewart Drewry, who in 1832 published a *Memoir of Suspension Bridges*, "The first European chain bridge was built in England across the Tees, . . . about 1741. From the account given of it, it was a very rude work, in no wise superior to the Chinese chain bridges, and the construction of suspension bridges does not appear again publicly to have engaged the attention of English engineers until 1814. . . .

"The construction of iron suspension bridges was begun in America in 1796, by Mr. Finlay, who in that year built one about 70 ft long, across Jacob's Creek on the road between Union Town and Greenburgh."

Finlay (or Finley) perfected his patent in 1808. By that time he had constructed at least seven more on the same general plan. They were:

Location	Span, in Feet	Width	Number of Chains
Falls of Schuylkill	306 (one pier in center)	..	2
Cumberland, Md.	130	15	2
Potomac	130	15	2
Wilmington, Del.	145	30	4
Brownsville, Pa.	120	18	..
Near Brownsville	112	15	..
Newburyport, Mass. . . .	244	30	7

Another interesting early book on suspension bridges is Thomas Pope's *Treatise on Bridge Architecture* (1811). Pope particularly tried to show that Finley's "invention" was nothing but a copy of the ancient Chinese bridges, and after making his comparison, went on to list objections to the Finley design, concluding: "Quere, whether a bridge of this kind, if it even possessed four times the strength it required in Summer, could in any wise be depended on in Winter . . . and as the breaking of one link would not only endanger the whole fabric, but very probably, utterly destroy it, how easy is it to prove that a structure so easily affected cannot be of long duration, and that, at the best, they are but mere temporary expedients."

For a "temporary expedient," it must be said that the old chain bridge at Lehigh Gap made a pretty good record.

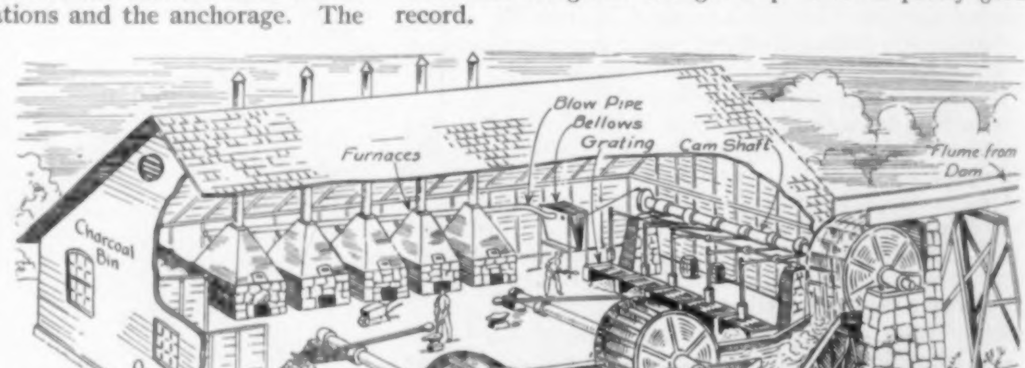


FIG. 4. THE ALBRIGHT AND CLARISSA FURNACE AND FORGE
As Envisioned by Mr. Jelly from Descriptions and Data Supplied by Old Residents of the Vicinity

Principles of Soil Stabilization

Outlining Properties of Soil Mixtures, Rational Proportioning Methods, and Special Processes

By W. S. Housel

Associate Member American Society of Civil Engineers

Associate Professor of Civil Engineering, University of Michigan, Ann Arbor, Mich.; Research Consultant, Michigan State Highway Department

Soil stabilization may be defined as any process of treating a soil mixture to improve its ability to resist deformation under load and to insure durability of the desirable state produced. Fundamental aspects of soil stabilization, particularly as applied to subgrades, are discussed by Professor Housel in the following article. Taking up in turn the properties of soil mixtures, rational methods of proportioning, and special stabilizing processes, he reviews present technique both in the field and the laboratory and points out that a number of important problems remain to be solved. Extensive investigations now under way may go far toward solution of these problems, but local conditions will always control. The article is abstracted from Professor Housel's address during the past year before the Twenty-second Annual Highway Conference at the University of Michigan.

In the last few years soil stabilization has become a subject of major importance in several fields of engineering, and highway engineers at present consider it the most promising and economical means of improving the vast mileage of secondary roads now demanding a higher type of construction. The value of stabilizing subgrade soils and constructing base courses by utilizing the soil available in place has been overlooked in the past only because of inadequate knowledge of soil properties and methods of improving them.

As far as soil mixtures are concerned, the two most important fundamental properties to be considered, from the standpoint of ability to resist deformation under load, are cohesion and internal stability. Cohesion may be defined as that property of a material which produces resistance to deformation by mutual attraction between particles, involving forces of molecular origin which are characteristic of microscopic and submicroscopic matter. This definition is intended to include both cohesion and adhesion as ordinarily defined.

Internal stability is that mechanical property of granular mixtures which produces resistance to displacement by the mutual support of adjacent particles in the mass, involving static forces and reactions between particles which are too large to be noticeably affected by molecular forces. The behavior of granular materials under stress can be described in terms of the stability of elementary arches of soil particles in which the ability to sustain vertical pressure is dependent on the horizontal thrusts supplied by adjacent particles in the mass. The conception of the soil arch leads directly to a definite criterion of failure, which is necessary for an adequate treatment of the stability of granular materials, and provides a logical basis for evaluating the soil resistance of mixtures possessing both cohesion and internal stability.

The most important of the properties which determine the structural durability or permanence of soil mixture are impermeability, capillarity, density, and flexibility. How long the subgrade will remain stable depends largely upon its impermeability or watertightness. Practically all soil mixtures, particularly if subjected to freezing temperatures, suffer from penetration of moisture into the voids, causing comparatively rapid disintegration.

Closely related to impermeability is the property of capillarity. High capillarity is objectionable in subgrade materials as it renders them incapable of drainage, and if water becomes available may in time result in excessive volume changes. In general, fine-grained soils have high capillarity and low permeability and are desirable only if they can be protected from excessive amounts of moisture over an extended period.

Making a Compacted Soil Sample by the Proctor Technique

Checking Stability by a Penetrometer Equipped with Hydraulic Gage

Scientific Control of Mechanical Soil Compaction Is a Recent Development

MIXTURES MUST WITHSTAND VOLUME CHANGES

To have permanent stability, a soil mixture must also possess the ability to withstand a certain amount of deformation and to expand and contract, within limits, without disintegration. Almost any soil mixture will be exposed to forces of expansion and contraction due either to temperature changes or to volume changes caused by the absorption of moisture, and some thought must be given to providing sufficient void space in the mixture to allow for expansion of the soil fines.

Density, another property which requires separate consideration, may

be expressed in terms of voids in the mixture or in terms of weight per unit volume or specific gravity. Density depends primarily upon the void characteristics of the materials used in the soil mixture, and density control is thus a direct means by which certain properties of the mixture can be controlled.

Among the relationships linking these various properties, perhaps the most important is that between stability and density. In the design of mixtures it is generally accepted that the greatest stability is produced by securing the greatest density or the minimum amount of voids. In concrete mixtures, for example, experimental evidence has shown conclusively that strength is dependent upon the void relationships, expressed either as the void-cement ratio or the water-cement ratio. However, with the exception of recent developments in methods of soil compaction, there have been few direct applications of density measurements to the design of soil mixtures.

But the criteria of maximum density cannot be followed blindly, since consideration must be given to providing ability to resist detrimental volume changes which may take place during the life of such a stabilized mixture. This consists largely in guarding against differential expansion and contraction of the mixture due to changes in moisture content. Several special tests have been devised to measure the effect of variation in moisture content. The older slaking tests have long been used to determine whether or not absorption will be so serious as to produce total disintegration. More recently "swell tests" have been used to measure directly the volume changes due to moisture absorption, and definite limits on the allowable amount of expansion are being determined. Shrinkage tests conducted by drying out small pats made from a soil mixture containing various percentages of water have also been in general use for determining excessive changes in volume.

STABILIZATION PROCESSES

Up to the present time the following basic methods of soil stabilization have been developed:

1. Mechanical compaction, as developed in the construction of earth-fill dams.
2. Proportioning of soil mixtures, as exemplified in the construction of stabilized roads.
3. Stabilization by the use of admixtures calculated to supply permanent cohesion or solidity to the granular mass.

In practice, all these methods may be combined to obtain maximum stability, but there are occasions when separate application is more feasible and economical. For example, the mechanical compaction of a natural subgrade may produce sufficient stability. Again, solidification of porous, unstable foundation soils has been accomplished by the injection of suitable chemicals. On the other hand, maximum stability may require mechanical compaction and in some cases additional stabilizing agents.

One of the more recent accomplishments in soil research is the scientific control of mechanical soil compaction, based upon construction methods and research initiated by R. R. Proctor, M. Am. Soc. C.E., of the Los Angeles Bureau of Water Works and Supply. The methods have been adopted by the U. S. Bureau of Reclamation and by several state highway departments in co-operation with the U. S. Bureau of Public Roads. Improvements are constantly being made through extensive researches carried out by these and other agencies.

The procedure consists in mechanical compaction of the soil at an optimum moisture content, making it possible to produce maximum consolidation. Such mechanical devices as the sheep's-foot roller are used in the work. It has been found desirable to regulate the water content of the soil at the time of compaction within rather narrow limits, the optimum moisture content being that amount which is sufficient to lubricate the soil particles without filling those voids that will remain when the soil has reached maximum consolidation. If any less water is used, the soil particles resist consolidation, while if more is used, the voids become filled with water and the soil is displaced rather than compacted under the roller.

The situation is directly analagous to that encountered in mortar-void tests with concrete mixtures, in which the mortar containing the minimum voids is obtained with the basic water content. Control of the moisture content of the soil and the degree of compaction can be effected by the usual laboratory analysis of samples or by a control test which has been developed by Mr. Proctor.

During the process of compaction, the density produced can be measured with sufficient accuracy by what has been called a plasticity needle or soil penetrometer. The penetrometer makes use of small plungers, with cross-sectional areas varying from 0.05 to 1.0 sq in., mounted on a compression spring which records the force necessary to penetrate the soil with the given plunger area. This simple test adequately measures the degree of compaction produced and, by proper correlation, the approximate water content of the soil. The degree of compaction thus measured is supplemented by frequent determinations of the weight per unit volume produced during construction. With such accurate means of control available, it is possible to insure compliance with detailed specifications requiring a given dry weight per cubic foot. The usual minimum limit is 90 per cent of

After Scarifying, the Soil Is Reduced to a Fine Mulch

Spreading Cement by Hand Is a Rapid and Accurate Method

TWO STEPS IN STABILIZATION WORK WITH PORTLAND CEMENT

Teeth of Sheep's-Foot Roller Prevent Lateral Displacement

Disk Rollers Are Also Efficient in Compacting the Soil

Compaction at Optimum Moisture Content Gives Maximum Consolidation

the maximum consolidation possible for any particular soil mixture.

PROPORTIONING SOIL MIXTURES

The proportioning of soil mixtures represents the next step that may be taken in addition to simple soil compaction. This type of soil stabilization is probably familiar to highway engineers as it has been developed largely in the construction of stabilized roads.

Gradation or mechanical analysis is commonly used in proportioning to produce maximum density. There are available as standards certain ideal curves with a gradation in particle size which will produce minimum voids or maximum density for any given maximum size of aggregate. Usually gradation specifications permit a considerable range in grading in order to allow the use of available materials.

For the purpose of design, materials are separated into components or soil fractions which usually consist of coarse aggregate, fine aggregate, and clay binder. Following the U. S. Bureau of Soils' classifications of particle size in the various soil fractions, as supplemented by developments in standard practice, the size limits of these fractions have been fairly well established.

Coarse aggregate, such as gravel or crushed stone, includes all material coarser than that passing a No. 10 standard sieve. Most specifications for coarse aggregate also include a limit on maximum size which may be as great as $1^1/_2$ in. Fine aggregate or sand usually comprises material passing a No. 10 sieve and retained on a No. 270 sieve, although there is some variation in the lower limit of the fine aggregate, and a great many specifications separate material on a No. 200 sieve. The binder, which includes clay and silt, consists of all material passing the No. 270 sieve.

The object in combining soil fractions is to provide an absolute volume of the finer fractions sufficient to just fill the voids in the coarser fractions. When applied to natural subgrades, separation into soil fractions forms the basis for volumetric analysis of the available material to determine its suitability or the corrective measures necessary to improve it. Maximum density is the fundamental consideration, and proportioning by gradation is not as direct as the method of combining absolute volumes of the soil fractions.

Material encountered in a given locality generally requires the addition of some particular sizes to fill in gaps in the grading. It is more convenient to deal with such problems by combining the separated sizes or soil fractions on a weight basis, leading naturally to the use of absolute volumes. The tests involved are a determination of the specific gravities of the constituents, of the weight per unit volume of the soil fractions and the finished mixture, and of absorbed moisture to reduce all factors to a dry-weight basis. These basic principles are used successfully in the mortar-void method of proportioning concrete mixtures, previously referred to.

In applying this method to the proportioning of a soil mixture, the first step is to determine the absolute volume of solids in a unit volume of loose coarse aggregate. The remaining void space in the coarse aggregate is then filled with soil mortar made of the proportions of fine aggregate and binder previously found necessary to produce a mortar of maximum density. This procedure may be varied by proportioning the mortar itself so that the loose volume of fine aggregate fills the voids in the coarse aggregate and the loose volume of binder or soil fines fills the voids in the fine aggregate. Trial mixtures are made up by varying the moisture to determine the optimum moisture content for effective compaction.

These methods appear entirely adequate whenever the stabilization process depends primarily upon water as a cohesive agent and also as a plasticizer during the compaction period. With the possible exception of bituminous materials, the use of any of the several chemical substances to aid stabilization should not invalidate the method of proportioning.

The void-filling characteristics of bituminous materials must be determined by further experimentation. At the present time similar problems in bituminous mixtures are more often controlled by surface-area requirements. While there may exist a direct relation between surface-area requirements and void characteristics of trial mixtures, the feasibility of using the latter as a design method for soil mixtures should be verified by further research.

THE PRINCIPAL COHESIVE AGENTS

In addition to the use of various soil fractions, it is customary to insure positive stabilization by including an admixture or chemical reagent which will supply cohesion. Among the cohesive agents that have been employed in the development of special stabilization processes, the following may be listed: Deliquescent chemicals which are depended upon to retain sufficient moisture to supply cohesion; bituminous materials such as asphaltic oils, cut-back asphalt, emulsions, and tars; portland cement; solidifying chemicals such as sodium silicate; and chemical reagents which neutralize detrimental colloidal instability.

The most common binding agent so far utilized is soil moisture, retained in the clay by capillary attraction, frequently supplemented by the use of some deliquescent

chemical such as calcium chloride. The natural moisture content of soil mixtures in stabilized roads varies through a rather wide range. In dry weather it is not sufficient to develop the cohesion required to prevent surface abrasion. Conditions in wet weather may be just as unsatisfactory because of excessive moisture. Chemicals with an affinity for water, used to remedy the dry-weather condition, are particularly effective where the soil mixture is exposed to abrasion. But even here results are not entirely satisfactory, as dust and loss of material persist during extended dry periods.

A FINISHED ROAD WITH A SMOOTH, COMPACT, STABILIZED MAT

In stabilizing subgrades not exposed to abrasive action and sufficiently confined, the most logical way of eliminating variation in moisture content appears to be by protecting the subgrade from moisture so far as possible. In this case the function of deliquescent chemicals would be chiefly to supply moisture for efficient and more rapid compaction during the period of construction.

The more recent advances in soil stabilization are being made through the use of other cohesive agents, including bituminous materials, portland cement, and chemical substances affecting the colloidal behavior of the soil fines. All these agents have been used to some extent, but as yet there has been insufficient experience to determine how far they will meet the wide range of conditions involved. It must not be concluded that almost any soil encountered in a subgrade can be stabilized successfully by merely mixing it with any one of a number of commercial admixtures. Such an optimistic viewpoint will do much to impede progress and perhaps also cause unfair prejudice against certain materials which may have been improperly used. New developments of this nature should be preceded by careful design and a reasonable period of experimental use.

When bituminous materials are employed, the object is to coat the soil particles with bitumen in order to supply cohesion for the stabilized mixture and prevent absorption of water by the fine soil particles. Successful performance of such a stabilized mixture over any extended period of time is dependent upon absorption phenomena which are today being subjected to investigation.

The water-asphalt preferential test, measuring the relative affinity of soil constituents for water and asphalt, has been developed in this connection. After a material has been thoroughly coated with bitumen, the mixture is agitated in water at 140 F for five minutes and the preference determined by the percentage of soil particles which separate out after displacement of the asphalt film by water. In performing this test on fillers for bituminous mixtures it has been found that certain materials in common use have very definite detrimental characteristics while others are just as definitely free from these objectionable properties. It has been further determined that the addition of certain chemicals reverses the harmful reaction sometimes shown by the preferential test. It seems fair to conclude, therefore, that application of the proper chemical reagents will in many cases make possible the use of soils which would otherwise be entirely unsatisfactory in a stabilized mixture.

Processes of this nature are also illustrated within common experience by the formation of natural hardpans. Here the weathering processes leach out certain chemical constituents which are carried downward and concentrated in certain zones, resulting in the formation of a soil hardpan that often would be quite acceptable as a stabilized subgrade. The work of Dr. Hans Winterkorn at the University of Missouri, directed along these lines, has led to some very interesting results which have been presented in several highway publications. This field is undoubtedly complex for any one except a specialist, and while it appears that a beginning only has been made, highway engineers may look with confidence towards developments of great practical value in soil stabilization.

The action of some other chemical substances which produce solidification within soil mixtures has been considered as a separate stabilization process. The distinctive phenomenon that produces beneficial effects peculiar to these particular binding agents appears to be the formation of a crystalline structure which binds the soil particles together and fills the voids in the mixture. The added strength ascribed to this crystallization tends to reduce both shrinkage and expansion. In the case of sodium chloride or common salt there is also some tendency to conserve the moisture content during periods of drying. This further reduces shrinkage and improves cohesion.

Portland cement, when added to soil for the purpose of stabilization, produces a cementation effect not unlike the solidification previously referred to, although differing in some degree. The physical processes of the cement in concrete-making are so generally recognized that it does not appear necessary to question whether or not a positive stabilization takes place. The main questions appear to be how much cement is needed and whether or not its use is economical. If the requirements set up are no more severe than in the case of other stabilization processes, the use of cement would appear entirely feasible. However, cement may be handicapped by the reputation it is expected to uphold, and it may be difficult for laymen and even engineers to forget concrete pavements when measuring the value of portland-cement stabilization.

It is interesting to note that as far back as 1919 road construction using a soil mixture stabilized with portland cement and some chemical reagent to eliminate the detrimental effects of moisture absorption was proposed under a commercial name. Logical as the idea may appear in this era of low-cost roads and soil stabilization, it was ridiculed and discarded at that time, as attention was centered on concrete pavements and high-type construction. This experience shows the danger in not recognizing the natural limitations of any type of construction. Soil stabilization, including newly developed methods and new uses of certain materials, has great possibilities if properly applied. But universal success regardless of special conditions cannot be expected, nor will the results compare with higher and more expensive types of road construction.

Economic Justification for Flood Protection

Deficiencies in Measuring the Feasibility of Proposed Projects, with Suggested Remedies

By Gilbert F. White

Secretary, Water Resources Committee of the National Resources Committee, Washington, D.C.

Under the Flood Control Act of 1936, a large-scale national program has been launched. In order to permit the wise selection of flood-protection projects to be included in this program, there is urgent need for a refinement of present technique for estimating the economic justification for each. Mr. White lists some matters of policy which require definition: Are potential as well as existing benefits evaluated? Are general as well as special benefits and costs evaluated? On what basis are total costs obtained and benefits computed? He then suggests a method for clearing up these questions as well as for remedying deficiencies in fact-finding technique, which result chiefly from lack of provision for systematic collection of data on past flood damages. In emphasizing the wide variety of bases now employed, Mr. White lists four different methods which have been used in calculating benefits and costs of protection works for the same flood-plain area.

Methods for measuring the economic justification for flood protection have failed to keep pace with methods for determining engineering feasibility. Although improved techniques for controlling floods have been developed and notable progress has been made in the study of flood flows (as reported in the "Progress Report of the Committee on Flood Protection Data," Proceedings for March 1935, and in the U. S. Geological Survey's Water Supply Paper No. 771, 1936, by C. S. Jarvis, M. Am. Soc. C.E., and others), little improvement has been made in techniques for estimating whether or not flood-protection works are justified on economic grounds. Technical thought concerning the economics of flood protection has advanced only slightly since completion of the Miami Conservancy District appraisals in 1921.

In its report on the omnibus flood-control bill of 1936 (H. R. 8455) the Senate Commerce Committee stated:

> The committee in the selection of the projects included in the bill as now reported to the Senate, has held to the principle that no project should be included therein which had not been reported by the Board of Engineers for Rivers and Harbors of the War Department as having economic justification, or involving the protection of human life.

Most persons probably will agree that an economically justified project is one in which the benefits from protection will exceed the costs, but few technicians will agree on how best to determine the ratio between benefits and costs. All who are familiar with the problem know that though one technician may find a given flood-protection project unjustified by a ratio of costs to benefits, another may find it amply justified through use of the same data but proceeding on different initial assumptions. Given assumptions sufficiently liberal, some flood protection could be justified on most flood plains in the United States. Given another set of assumptions, only a slight amount of new flood-protection work could be shown as justified.

Current methods for estimating economic justification for flood protection vary greatly, and are confused and nebulous in addition. In its recent report, the Society's Committee on Flood Protection Data has directed special attention to what it terms "the chaotic condition" of flood economics (Proceedings for March 1936).

No uniform economic analysis of flood protection was employed in the nation-wide "308" surveys of flood control and water utilization conducted by the Corps of Engineers during the past seven years. Those studies, together with numerous others by private engineers, now provide an instructive array of estimates made by various methods.

For several reasons, the present seems an appropriate time to take stock of current policies and techniques. A large-scale national flood-control program has been launched under authority of the Flood Control Act of 1936. As projects of undoubted justification are completed, marginal projects will require evaluation, and the need for refinement of method will become more urgent. Moreover, national and regional programs of the type outlined in this act require a relatively uniform basis of evaluation if there is to be a reasonable choice of projects. A few state conservancy-district laws provide that a favorable ratio between costs and benefits must be established before construction work is undertaken, and this ratio may also be highly important in deciding which one of several protection schemes differing in cost is finally chosen. This paper reviews briefly the chief deficiencies in public policy with respect to estimating economic justification for flood protection, indicates the chief deficiencies in the techniques utilized in making such estimates, and suggests in each case means of remedying these weaknesses.

A Silt Deposit of 2 to 3 Ft Covers This Texas Cornfield
The Deposit Consists of Soil Swept from an Unprotected Field

Deficiencies in Public Policy

Most technicians, in reporting on possible means of controlling floods in a given area, must assume public policy at no less than five important points. Lacking a definition of policy by the public group concerned, the engineer is in most cases obliged to make his own. Of these five problems of policy, two relate to the estimation of benefits, two to the estimation of costs, and one

The Industrial and Commercial Sections of the City

AIR VIEWS IN BINGHAMTON, N.Y., DUR-

to the comparison of benefits and costs. These problems, which are discussed at some length in my paper on "The Limit of Economic Justification for Flood Protection" (*Journal of Land and Public Utility Economics* for May 1936), may be outlined briefly as follows:

1. In any evaluation of flood-protection benefits it is necessary to decide whether or not potential as well as existing benefits are to be measured. Potential benefits, or those which would accrue through a change in economic activity in a flooded area following the completion of protection works, are in the nature of reclamation. They comprise such increments in value as arise when a mud flat within a densely settled city area is made suitable, through flood protection, for building purposes, or when low-lying pasture land is made available for truck-farming. In most projects, potential benefits have been ignored. Attention has been restricted to existing benefits, as measured by those losses which would be prevented were existing uses of the affected land to be continued. If existing benefits alone were taken into account, it would never be feasible to protect many unoccupied or sparsely settled lands of great potential value for urban and rural use. Nevertheless, the greater proportion of estimates of benefits by the Corps of Engineers has been limited to a consideration of existing benefits.

2. It is necessary to decide whether or not general benefits, or those which accrue to a community at large both within and without the flooded area, are to be evaluated together with special benefits—those accruing to specific properties and interests within the flooded area. Analysis commonly is restricted to direct increments of productivity in the area affected, although so-called "intangible" benefits have long been thought to exist. In certain cases, such as the Miami Conservancy District, the general benefits have been estimated as approximately 100 per cent of the special benefits, as reported in *Engineering News-Record* for November 16, 1922. Obviously, the inclusion or exclusion of general benefits may profoundly affect the final decision with respect to the feasibility of a given project.

3. There is the problem of whether or not far-reaching and general costs, as well as special construction costs, are to be evaluated. It seems probable that many levee projects—such as some of those of the Illinois River—which may have been shown to be justified on the basis of direct construction costs, would never have been built in their present form if the general expense to which interests downstream were put through the construction of the river channel and the resultant increase of flood crests had been evaluated also. This again is a question of policy—of whether or not a local, state, or national government wishes to recognize general costs even though not forced to do so under common law.

4. There is the problem of whether or not costs should be capitalized and amortized for the estimated life of the protection works, or for some other period. This question depends upon the attitude of the beneficiaries with respect to protection. They may regard

TABLE I. TYPICAL FORMULAS USED BY THE CORPS OF ENGINEERS IN ESTIMATING ECONOMIC JUSTIFICATION FOR FLOOD-PROTECTION PROJECTS

FORMULA	SOURCE (308 REPORTS)
(1) $E = \dfrac{P\left(\dfrac{D_a}{Q_a}\right)}{C + PA}$	Yazoo River, H.D. 198, 73d Cong. 2d Sess., Paragraphs 125–130
(2) $E = \dfrac{P\left(\dfrac{D_a + D_b + \ldots + D_n}{N}\right)}{C + PA}$	Arkansas River, H.D. 308, 74th Cong., 1st Sess., Vol. 1, Paragraphs 5–11 incl., Appendix No. 6
(3) $E = \dfrac{P\left(\dfrac{(D_aR)Q_a \ + \ \ldots \ (D_nR)Q_n}{Q_P}\right)}{C + PA}$	Yellowstone River, H.D. 256, 73d Cong., 2d Sess,. Paragraph 200 (Proposed, but not used)
(4) $E = \dfrac{\dfrac{D_a}{(1+i)} P}{C}$	Hoosic River, H.D. 684, 71st Cong., 3d Sess., Paragraph 22

NOMENCLATURE

E = economic justification
C = construction cost
A = annual maintenance and operating cost
D = recorded or estimated damage: D_a for year a, D_n for nth year of record
N = number of years of record of flood damage
R = coefficient of increase to allow for future appreciation of property subject to damage
P = period of capitilization in years
Q = flood frequency: Q_a for flood in year a, Q_P for flood of, period P
i = compound interest rate

flood-control work as an investment (*a*) to be liquidated over the life of the works, (*b*) to be liquidated over a short period of years adjusted to the prevailing interest rates on actual self-liquidating projects, or (*c*) as an investment continuing indefinitely without repayment. A slight change in the interest rate (chosen arbitrarily without reference to the utility of protection) may spell the difference between justification and non-justification, or between one type of construction and another.

5. Finally, the time period for discounting benefits

A Residential Section Under Water

ING THE CHENANGO FLOOD OF JULY 1935

in order to compare them with costs may be determined in any one of a dozen ways without violating precedent. Benefits may be calculated for the period of record of damages, for the life of protection works, for the period of a hypothetical flood cycle, or for an arbitrary period set by current interest rates. Table I is a tabulation of some typical methods of calculating benefits and costs.

TABLE II. PRESENT VALUE OF FLOOD PROTECTION AT KANSAS CITY, KANS., AND KANSAS CITY, MO.

FORMULA	ESTIMATED PRESENT VALUE OF FLOOD PROTECTION
(1) $P\left(\frac{D_a + D_b + \ldots + D_n}{N}\right)$	$1,344,800
a to n = all floods of record	
(2) $P\left(\frac{D_aV + D_bV + \ldots + D_nV}{N}\right)$	11,456,000
a to n = selected floods of record	
(3) $P\left(\frac{R(D_aV + D_bV + \ldots + D_nV)}{Q}\right)$	6,636,500
a to n = all floods in hypothetical cycle	
(4) $\frac{D_aQ_a}{(1+i)^a} + \frac{D_bQ_b}{(1+i)^b} \ldots + \frac{D_nQ_n}{(1+i)^n}$	9,149,374
a to n = all floods in hypothetical cycle	

(Source: House Document No. 238, 73d Congress, 2d Session, Missouri River, Paragraphs 235–238)

NOMENCLATURE

D = recorded or estimated damage: D_a for year a, D_n for nth year
N = number of years of record of flood damage
P = period of capitalization in years
Q = flood cycle in years; Q_a = frequency of flood a in years
R = coefficient of increase to allow for future appreciation of property subject to damage
V = coefficient of correction to bring past damages up to present value
i = compound interest rate

The use of slightly different methods for a single flood-plain area may yield results so diverse, as shown in Table II, as to cast doubt upon the validity of any one of them. The choice of a method is of more than academic interest, because the design and cost of protection works may be scaled in proportion to the benefits.

All the foregoing problems of policy are unsettled in so far as the federal government and most state governments are concerned. For example, a federal engineer can with propriety submit an estimate using any one of the formulas shown in Table I. Furthermore, it is difficult to find estimates for projects in any two drainage basins which are precisely alike in the assumptions made for each of the five points previously mentioned. The House committee's report on an early draft of the omnibus flood-control bill quoted, from reports by the Corps of Engineers, numerous precise ratios of cost to benefit. These ratios were set up on almost as many bases as there were district engineers submitting reports. Moreover, it is a rare report which states explicitly what assumptions have been made and that they represent merely the opinion of those preparing the report. Ratios between benefits and costs are presented to municipalities, to conservancy districts, and to Congress as though they were precise and not dependent upon rough estimates and arbitrary premises of policy. As a result, the basic issues at stake are not recognized clearly by the administrators, legislators, and voters who are expected to approve or disapprove projects, and no equitable basis for comparing projects is in use.

As a first step in correcting the deficiencies in policy that have been noted, it is suggested that all future estimates of economic justification contain a clear statement of the assumptions made with respect to the five questions previously mentioned. Lucid statements concerning these matters would facilitate the appraisal of estimates by laymen and engineers. They also would aid comparisons of unlike methods, and would encourage technical discussion of problems of estimation which heretofore have not been faced squarely. This improvement would be brought about in large measure if the chief of engineers, the secretary of agriculture, and appropriate state officials were to stipulate that such statements be made in connection with all future flood-control reports.

As a second step, it is suggested that, wherever practicable, all estimates on groups of projects to be considered for inclusion in the national or regional flood-control program be set up on a comparable basis.

Finally, it is suggested that efforts be made to secure a definition by Congress of federal policy with respect to the five points previously noted. Well-defined policy could not be expected to emerge at once. Careful consideration of the practical application of alternative policies would be required. There has been a crystallization of federal policy in a few respects, but the heterogeneous nature of the estimates on which the Flood Control Act of 1936 is based affords ample evidence of the confusion which now exists. In view of that confusion, and as a means of promoting constructive action, the responsible federal departments might well attempt

to clarify outstanding problems and to submit recommendations for congressional consideration. Such an effort should make use of geographic and economic experience as well as experience of the types represented in the Society's Committee on Flood Protection Data.

DEFICIENCIES IN TECHNIQUE

Even though all problems of policy were solved satisfactorily, there would still remain numerous deficiencies in estimating technique. These relate chiefly to the collection of data on flood damage and to the appraisal of general and special benefits.

THIS FLOOD PLAIN AREA ALONG THE MISSOURI RIVER AT KANSAS CITY IS ZONED FOR INDUSTRIAL USE

Notwithstanding the fact that most estimates of the feasibility of protection works are based on computations of benefits using data on past flood damages (a procedure which I consider unsound), there is no provision for the systematic collection of such data. The Weather Bureau makes rough estimates of damage caused by flood; the district offices of the Corps of Engineers take censuses of flood damage in many areas; the Division of Disaster Relief of the American Red Cross publishes reports of damages from major flood disasters; and several other agencies make occasional studies of flood losses. The Weather Bureau and Red Cross reports are not detailed or complete, while the studies of the Corps of Engineers vary greatly in degree of detail from one part of the country to another. Following the 1936 flood in a large eastern city, no less than five federal agencies made independent estimates of damages.

It is suggested that provision be made in the future for a single reliable census of damage following each important flood. The responsibility for initiating the systematic collection of such data would seem to lie with the federal government, but the actual field work in many areas might well be delegated to state or local agencies.

It is suggested further that every census of flood damage be based on a single standard enumeration schedule prepared by engineers familiar with flood conditions in various parts of the United States. At present many different schedules are in use, and not infrequently the same schedule is not used for two successive floods in the same area. One survey includes damages to existing levees, another does not. One engineer counts "hoped-for gain" from crops; another disregards that item but includes a "loss of retail business" item which the first neglects. Moreover, certain workers utilize systematic sampling systems for field surveys while others depend upon casual reconnaissance.

It is suggested that a coordinating group be organized to draw up a census schedule for flood damage and directions for its use sufficiently flexible to suit it for national application. Recently a subcommittee of the Water Resources Committee has been created to deal with this problem. Brig. Gen. Max Tyler is chairman.

General benefits have been the subject of wide discussion, but there have been no systematic efforts to measure or appraise them. It is believed by some workers that general benefits exist and that they vary in accordance with the economic structure of the area affected by flood. These hold, for example, that the ratio of general to special benefits is greater for a commercial area in a large city than for a remote farm. Other workers deny the measurability of general benefits, and still others deny their existence. It may be said in any case that if they exist they would be costly to measure. No one has made a careful study of the extent to which the economic and social activity of a community, state, or nation as a whole is affected by flooding in a part of its area.

The validity of the concept of general benefits should be tested by intensive investigations focused on a few selected flood-plain areas. Such investigations might reveal the nature and magnitude of the general benefits, if any; their areal incidence; and their ratio to special benefits in areas of diverse economic activity. On the basis of such work, it might be possible to estimate approximately the amount of general benefits in any area in which special benefits had been measured, if, for example, population density, distribution of public utilities, and major use of land also were known.

ESTIMATING SPECIAL BENEFITS

Two general methods for measuring special benefits have been developed. The so-called "damages" method consists in estimating the damages which would occur if protection were not furnished. The so-called "differential" method consists in estimating the difference in the value of property before and after flood protection is provided, taking into account probable damages.

Although the differential method of estimating benefits has been used to levy assessments for flood protection in a few urban and rural areas, it has not had wide application to the reconnaissance work necessary in such investigations as those resulting in the "308" type of report. I believe that this method is far more satisfactory than that based on damages. There have been no comparative studies, however, to determine the actual difference in estimates obtained by using the two methods for the same area. Therefore it is suggested that selective experimentation be initiated to discover the discrepancies in estimates arising from use of these two methods. Such sample studies would be useful in developing accurate reconnaissance techniques.

ENGINEERS' NOTEBOOK

From everyday experience engineers gather a store of knowledge on which they depend for growth as individuals and as a profession. This department, designed to contain ingenious suggestions and practical data from engineers both young and old, should prove helpful in the solution of many troublesome problems.

Discharge Over a Free Fall

By Walter B. Langbein, Jun. Am. Soc. C.E.

Junior Engineer, U. S. Geological Survey, Washington, D.C.

With greater attention being paid to problems of floods and flood runoff, the determination of peak discharges by indirect hydraulic methods becomes increasingly important. The U. S. Geological Survey has used such methods both (1) to aid in defining the upper portion of stage-discharge curves at regular gaging stations, and (2) to determine the flood-peak discharges on streams not ordinarily gaged. The methods are in general well known and include slope areas (varied-flow equation), dams treated as weirs, and discharge through contracted openings. They are described in U. S. Geological Survey Water-Supply Papers 636C and 773E.

There is still need, however, for a general expression for discharge, applicable to a wide variety of conditions. It is the purpose of this article to review briefly some of the present formulas and to suggest a more general approach that is believed worthy of consideration. The notation used is explained at the end of the article.

In Water-Supply Paper 773E, page 254, Hollister Johnson, Assoc. M. Am. Soc. C.E., refers to the use of the free-fall method in computing miscellaneous flood discharges in southern New York during the flood of July 1935. "The flow over falls," he states, "was computed by the formula $Q = 5.67\ LH^{1.5}$. The results from this method were not very satisfactory. The steep slopes of the water surface in the channels above the falls caused velocities greater than the critical velocity at the falls section and thus made the falls section ineffective as a control." Mr. Johnson is justified in his criticism of the results. The formula assumes that the velocity at the brink is exactly critical under parallel flow. Flow at the falls is not amenable to expression by the equation for varied flow, as the conditions comprise local phenomena. (See B. A. Bakhmeteff's *Hydraulics of Open Channels*, pages 28–29.)

In an article in Civil Engineering for April 1936, entitled "Discharge Characteristics of the Free Overfall," Hunter Rouse, Assoc. M. Am. Soc. C.E., demonstrates that the critical depth at a free fall at the end of a channel with nearly level bottom occurs at some distance (variable) upstream from the brink, but nevertheless he recommends that the control point be taken at the brink, where the equation $Q = 9.4\ bd_0^{1.5}$ expresses a more nearly correct relationship.

Rouse also discusses the nature of the surface curve and the non-static distribution of internal horizontal pressure within the channel and weir nappe. However, instead of proceeding to express quantitatively the horizontal distribution of pressure, he derives his equation by computing the coefficients of velocity and contraction in the basic weir formula for a weir of zero height. The contraction coefficient is computed to be constant and equal to 0.715. This value, Dr. Rouse states, has been experimentally verified as the ratio between crest depth and critical depth. This ratio is similar to Bakhmeteff's coefficient β, which is defined by the relationship $d_0 = \beta^{3/2}\ d_c$ (Transactions, Vol. 96, 1932, page 430).

Other equations for discharge at a free fall have been derived in a similar manner. In Water-Supply Paper 200, page 135 (R. E. Horton, 1907), the formula given is $4.74\,LD^{3/2}$. In King's *Handbook of Hydraulics* (first edition, page 142, 1918), the formula is $5.21\,LH^{1.47}$, where D and H both refer to the depth of flow at the brink, and L is the breadth of flow. Both of these equations have been developed by applying the basic weir formula to a weir of zero height; that is, the term for velocity of approach has been evaluated by letting $v_a = \frac{Q}{bh}$. If, instead, this term had been evaluated by assuming that just back of the falls the flow is at critical depth, then $\frac{v_a^2}{2g}$ could be equated to $h/2$, and the formula obtained would be $Q = 9.8\,mbh^{3/2}$.

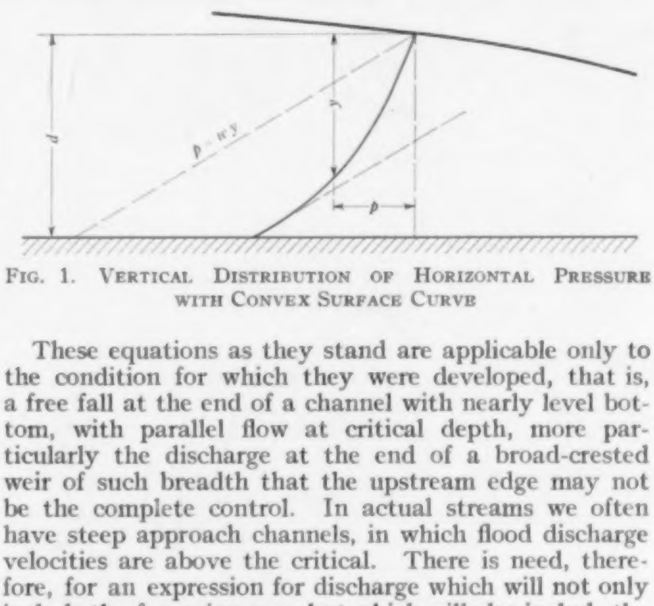


Fig. 1. Vertical Distribution of Horizontal Pressure with Convex Surface Curve

These equations as they stand are applicable only to the condition for which they were developed, that is, a free fall at the end of a channel with nearly level bottom, with parallel flow at critical depth, more particularly the discharge at the end of a broad-crested weir of such breadth that the upstream edge may not be the complete control. In actual streams we often have steep approach channels, in which flood discharge velocities are above the critical. There is need, therefore, for an expression for discharge which will not only include the foregoing case, but which will also include the more general condition where the approach velocities are greater than the critical velocity.

An approach to a solution is best obtained by considering the nature of the surface curve and attempting to evaluate the pressure distribution within the channel. To avoid the hopeless complication of an analytical solution, various assumptions have been suggested. B. A. Bakhmeteff (Transactions, Vol. 96, 1932, page 427 et seq.) discusses a problem in which it is assumed that the filaments of flow are concentrically circular, and that the velocities are distributed in such manner

that VR remains a constant. For a free fall this assumption appears unsuitable, since it would require that at the bottom, where R is nearly infinite, the velocity would approach zero, while velocities would increase toward the surface—a condition which is inconsistent with the present conception of weir discharge.

Another assumption by S. M. Woodward, in "Technical Reports of the Miami Conservancy District" (Part VII, page 135 et seq.), appears to satisfy conditions. He considers that curvature of the filaments of flow results in a vertical acceleration, which, since flow is convex, in effect decreases the weight of the moving liquid so as to produce the vertical distribution of horizontal pressure shown in Fig. 1. The acceleration is assumed to be zero at the base and to increase uniformly to a value of a_0 at the surface. Accordingly, the acceleration at any point at depth y is

$$a = a_0\,(1 - y/d)$$

and the horizontal pressure intensity,

$$\frac{p}{w} = \left(1 - \frac{a_0}{g} + \frac{a_0 y}{2gd}\right) y$$

Since, in general, $a = \dfrac{v^2}{R}$ and $R = \dfrac{v^2 d}{a_0\,(d - y)}$, the radius of curvature is infinite at the base (where $y = d$), and at the surface it is equal to $\dfrac{v_0^2}{a_0}$. The surface acceleration, a_0, has a value of zero at the point where surface drop-off begins, and increases downstream to an assumed value of g at the brink. The latter value makes the total horizontal pressure at this section a minimum, with the intensity at no point less than zero.

Upon this basis an expression for the surface curve is derived by applying the law of the conservation of momentum:

$$12\left(\frac{v_1^2}{2g}\right) d_1^2 - 12\left(\frac{v_1^2}{2g}\right) d_1 d = 3d_1^2 d - 3d^3 + 2\left(\frac{a_0}{g}\right) d^3 \quad . \quad [1]$$

In Eq. 1 the subscript "1" refers to the upstream section where drop-off begins.

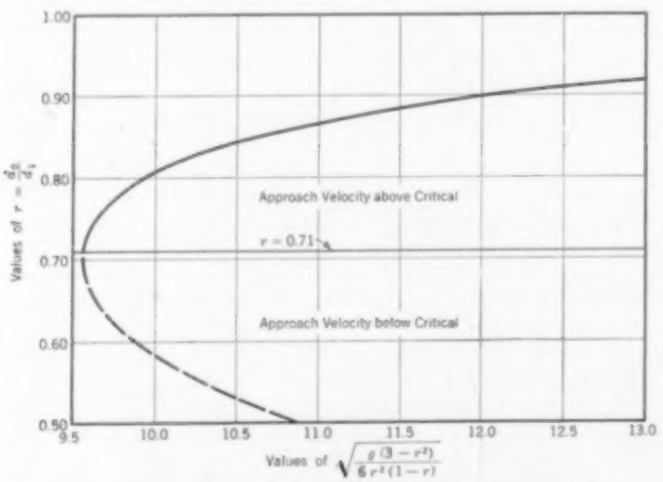


FIG. 2. VALUES OF THE COEFFICIENT IN EQ. 2 FOR VARIOUS VALUES OF r

Evaluating Eq. 1 for the particular case described in Dr. Rouse's paper, in which the velocity at the upstream section is critical $\left(\dfrac{v_1^2}{2g} = \dfrac{d_1}{2}\right)$, the value obtained for $\dfrac{d_0}{d_1} = \dfrac{d_0}{d_c}$ is 0.71. This compares favorably with Dr. Rouse's value of 0.715.

Having interchecked these two methods, one can proceed to derive an expression for discharge in the general case. Equation 1 may be solved for discharge Q in terms of the depth at the brink by evaluating as follows:

$$d = d_0 \text{ (at the brink where } a_0 = g); \quad r = \frac{d_0}{d_1};$$

$$Q = bd_0 v_1 / r$$

After making the above substitutions, we obtain:

$$Q = \sqrt{\frac{g\,(3 - r^2)}{6r^2\,(1 - r)}}\; bd_0^{3/2} \quad . \quad . \quad . \quad . \quad . \quad [2]$$

The value of r need be only approximately known. Values of the quantity under the radical, for various values of r, are given in Fig. 2. It is to be noted that the minimum value of the radical occurs when $r = 0.71$, and agrees fairly well with the 9.4 obtained by Dr. Rouse.

While the foregoing analysis should be reasonably correct, it may be pointed out that it rests upon a somewhat empirical basis and that definite experimental confirmation is lacking.

NOTATION

Q = discharge in cu ft per sec
d_0 = vertical depth of flow at brink or crest of fall
d_1 = depth at upstream point where surface drop-off begins
d_c = hydrostatic critical depth
y = depth coordinate measured from surface, in ft
v = velocity, in ft per sec
v_a = approach velocity
v_0 = surface velocity
a = acceleration, in ft per sec per sec
a_0 = acceleration at surface
g = acceleration due to gravity
w = unit weight of water
p = hydrostatic pressure, lb per sq ft
r = d_0/d_1
R = radius of curvature of filaments of flow
b = breadth of flow

A Mechanical Assistant for Drawing Contour Lines

By CHARLES C. BAYLES, JUN. AM. SOC. C.E.
STATE HIGHWAY OFFICE, ASTORIA, ORE.

A SIMPLE and steady tripod support for a contour pen is shown in Fig. 1. The legs are soldered at their upper ends to an ellipsoidal tube with its minor axis of approximately the same diameter as the pen handle. A wing screw operates perpendicular to the short axis of the ellipse to hold a standard curve pen firmly in place against the opposite side. The legs extend about $1^1/_2$ in. horizontally from the central tube and about $1^1/_4$ in. vertically from the drawing surface, and are carefully smoothed at the contact points to permit easy operation.

For proper operation the pen should be nearly perpendicular to the drawing surface. This adjustment may be made accurately by bending the legs or by placing a layer of soft rubber around the pen handle at its point of contact with the set screw. The rubber cushion allows a slight amount of rotation in any direction so that as the tripod is pushed forward the friction of the pen on the paper tends to hold the lower part of the pen slightly to the rear in the direction of motion—a position even more conducive to correct operation than to have the pen accurately vertical.

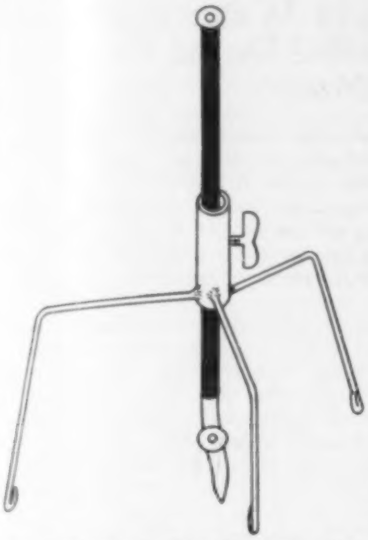


FIG. 1 STANDARD CONTOUR PEN WITH TRIPOD ATTACHMENT

I have discovered a few tricks in the operation of the tripod that aid materially in producing the fine results of which the pen is capable. One is to rest the forearm of the operating hand on the table top, producing all the motion with the wrist and fingers, the line of motion to be always towards the draftsman. This movement is not an inconvenience in most cases, since the pen generally starts from a stopped position on the line without leaving a dot, even after a pause of several minutes. These pauses give the draftsman an opportunity to adjust his paper to the best advantage.

The tripod is best operated by grasping the central tube, just below the wing screw, with the thumb and index finger. On turns, particularly very sharp ones, the left hand may be used to hold one leg of the tripod in place while the right maneuvers the pen around the curve without danger of lateral motion. The pen may also be pivoted about a point by pressing lightly downwards on the tripod to force the pen point into the drawing surface and at the same time rotating the pen by a lateral motion of the tripod.

Slide Rule for Soil Analysis

By GEORGE A. LEE, JUN. AM. SOC. C.E.

SOIL TECHNICIAN, MOGADORE DAM, BUREAU OF WATER SUPPLY, CITY OF AKRON, OHIO

IN soil analysis, the size of particles less than 0.02 mm in diameter is generally determined by the Bouyoucos test. A 50-gram sample of the soil is dispersed in a liquid, usually water, in a 1,000-cc graduate containing an immersion hydrometer. The factors of time, hydrometer reading, and temperature furnish sufficient information for computing the grain size for the several percentages.

A slide rule devised by the author (Fig. 1) greatly expedites the calculations. The scale divisions for grain size, temperature, and time interval of settling are based on Stoke's law of small spheres falling in a liquid. The spacing of the scale for hydrometer readings must be determined from a calibration of the hydrometer made by the well-known Casagrande method.

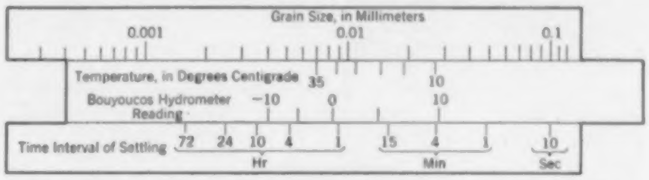


FIG. 1. SLIDE RULE FOR COMPUTING RESULTS OF BOUYOUCOS TEST

The grain diameter, d, depends upon five factors: The specific gravity of the grains, s; the specific gravity of the fluid, s_1; the viscosity of the fluid, n; the time interval, T; and the depth of fall, H, measured by the hydrometer reading.

For convenience, the specific gravity of the soil is assumed to be 2.7; however, this factor can be varied if desired. The specific gravity of the fluid, which is usually water, is then taken as 1.000. The viscosity of the fluid varies inversely as the temperature. The time interval is noted. The reading on the hydrometer will give the depth of fall through which the grain sizes are computed.

Stoke's law may be expressed as:

$$d^2 = \frac{18nH}{(s-s_1)T}$$

Letting K equal $\frac{18n}{s-s_1}$, and writing the equation in logarithmic form, we have $2 \log d = \log K + \log H - \log T$. Now K is a function of the temperature, and H varies with the reading of the hydrometer as it sinks into the mixture. Then, by tabulating K, H, and T values and their logarithms with the corresponding values for temperature, hydrometer readings and time, a slide rule may be constructed to give a solution.

In using the rule, each point on the grain-size curve requires only one setting of the slider. It should be noted that any changes made necessary in the rule by variations of equipment and local conditions affect only the slider. Further, the scales for several hydrometers may be placed on a single slider.

Our Readers Say—

In Comment on Papers, Society Affairs, and Related Professional Interests

One Record Hard to Beat

TO THE EDITOR: Readers of CIVIL ENGINEERING may be interested in a quotation on the construction of the Central Pacific Railway taken from an old book. This excerpt from *California for Health, Pleasure, and Residence*, which was published in 1874, is as follows: "One incident of the building of the road will conclude what I have to say of it. In April 1869, ten miles of road were built in one day. This is probably the greatest feat of railroad building on record. What is most remarkable about it is that eight men handled all the iron on this ten miles. These eight giants walked ten miles that day, and lifted and handled one thousand tons of rail bars each."

"Giants" is right. This would have been a remarkable feat, even in California—8,000 tons on 10 miles is 800 tons per mile. This means a section of rail weighing 509 lb per yd, or 5,090 lb for a rail 20 ft long. Since each rail was lifted and handled by four men, each had to lift 1,272 lb, and do it 1,760 times in one day.

However, there was some foundation for the 10 miles laid in one day. *Rails and Trails*, the biography of the late Grenville M. Dodge, Hon. M. Am. Soc. C.E., mentions that it was done on a bet. But several days were first spent in carrying forward and placing in position the ties, rails, and fastenings, so the work consisted chiefly of lifting the rail on the ties and spiking it. That was not "tracklaying." I have some recollection of John Painter's showing me a watch given him by the directors of the Texas and Pacific Railway for laying a little over two miles (I think it was) in one day, and this was called the record at that time.

C. D. PURDON, M. Am. Soc. C.E.

St. Louis, Mo.
March 26, 1937

A-Frame Structure Arouses Interest

DEAR SIR: The photograph of the A-frame structure, shown in the letter by T. C. Forrest, Jr., Assoc. M. Am. Soc. C.E., on page 230 of the March issue, illustrates an ingenious solution of a structural problem.

This structure appears to be a three-hinged arch. The two legs of the A-frame seem to bear against each other at the top and to approximate a hinged condition at that point. The lower ends of the legs apparently rest on top of the pipe, approximating hinges at these points also. The horizontal thrust of the two legs seems to be resisted by the pipe itself.

This structure would be a king-post truss if the pipe were supported by one hanger only at the center. But its character is changed to an arch by the fact that the pipe is supported at intervals (similar to the floor hangers of an ordinary arch bridge). There would be no question about what type of structure this is if the two legs of the A-frame were bowed as in an ordinary arch, and the fact that they are straight does not alter the character of the structure.

H. D. HUSSEY, M. Am. Soc. C.E.
Designing Engineer, American Bridge Company

New York, N.Y.
March 25, 1937

TO THE EDITOR: The letter (with its accompanying photograph) by T. C. Forrest, Jr., Assoc. M. Am. Soc. C.E., in the March issue, arouses my interest in the subject of unusual bridge structures.

BRIDGE TRUSS BUILT OF STEEL RAILS

It reminds me, in fact, of a small bridge that I saw several years ago in the yard of a manufacturing firm about 50 or 60 miles from New York City. The truss, which was made of steel rails, was fabricated and erected by the workmen. The accompanying photograph of it may be of interest.

ROBINS FLEMING
American Bridge Company

New York, N.Y.
March 26, 1937

Surge Problems in Water and Sewer Systems Studied by the Use of Models

TO THE EDITOR: In view of the fact that there has been a dearth of information in technical literature on surge problems as applied to water and sewerage design, Arthur B. Morrill, M. Am. Soc. C.E., and Harry Kallgren are to be commended for their excellent and timely paper on the subject in the March issue. Possibly the surge problem has become of more importance since the wide adoption of electric motor-driven pumps in sanitary engineering work.

Generally, surge problems in simple conduit systems of a single branch of uniform diameter and flowing full can be satisfactorily solved by analytical methods. But problems arising in complicated systems, with many branches of non-uniform diameter, are more easily solved by model investigation. Some of the many problems confronting the designer dealing with such systems include the determination of surge draw-down due to starting a pump; the reduction of surge effect at the surge tank, when the conduit is flowing partly full at the time surge starts; and the effect of surge resonance in a branched system, in which case surge waves reflecting from different points may accumulate at a common point. These and other similar problems should be thoroughly investigated by carefully conducted model studies in a well-equipped hydraulic laboratory in order to increase the available professional knowledge on the subject.

In general, when spilling-type surge wells are used, all the spill occurs during the first half of the surge cycle. This is due to the fact that all the energy available for raising the water in the surge well above the crest of the weir is dissipated by the discharge over the weir; at the moment when the water recedes to the crest of the weir and spill ceases, the remaining available energy is represented by the height of the water surface at this point. Part of this remaining energy is dissipated by friction before the water surface reaches a maximum for the second time, and therefore subsequent surge rises will reach peaks lower than the crest of the weir.

The method, used by Messrs. Morrill and Kallgren, of reducing the complicated actual sewer of varying diameter to an equivalent interceptor of constant diameter and then designing the model on the basis of this imaginary prototype is very interesting. It would be justifiable to assume that if the assumed prototype developed kinetic energy equivalent to the actual sewer, the surge effects would be equivalent. It is to be hoped that tests to determine surge effects of the sewer system can be made when construction is complete in order to check the model test results.

The use of the factor α as coefficient in the formula for kinetic energy is somewhat of an innovation. It is obvious that actual velocity distribution in a conduit produces higher values of kinetic energy than the average velocity. The general use of this factor should result in much greater accuracy of analytical solutions of surge problems.

Even though model studies are often more satisfactory than analytical methods for solving surge problems, the results of such studies may be somewhat in error if proper precautions are not taken in collecting and interpreting the data. Great care must be taken in duplicating flows in the model because of the small scales necessary in model work. Elevations to which water will rise may be in error because of the fact that the computed hydraulic gradient elevations are always lower than the actual, due to the use of safe values of coefficients in hydraulic formulas. Model characteristics must be measured very carefully, and the model should not be changed in any manner after these measurements are made and the various ratios computed.

In the particular study referred to by Messrs. Morrill and Kallgren, the model was constructed and tested and the report submitted in less than a month, which is somewhat of a record for prompt solution of a tedious problem.

ARTHUR C. MICHAEL, Assoc. M. Am. Soc. C.E.
Assistant Mechanical Engineer, Department of Water Supply, City of Detroit

Detroit, Mich.
April 6, 1937

Additional Solution for Backwater Formula

To the Editor: In the March issue of Civil Engineering, R. L. Irwin, Jun. Am. Soc. C.E., presented a graphical solution of Manning's backwater formula, which he had reduced to the form $h_m = \left(\frac{Q}{K}\right)^2$. The K curve of his Fig. 1 suggests another graphical solution that may be of interest.

The curve is not theoretically a parabola, as the values of K depend on A and R, which in natural channels do not vary in any fixed relation to surface elevations. However in many sections approaching the rectangular in shape, a parabola would closely represent the relation.

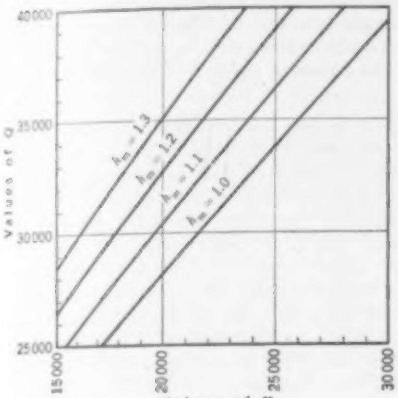


Fig. 1. Relation Between Q and K for Various Values of h_m

Let E be the surface elevation, and let the subscripts 1 and m apply to the lower end of the reach and the middle of the reach, respectively. The formula representing the curve would in general be $E - G = aK^n$, a, G, and n being constants. For the middle section $E_m - G = aK_m^n$, and for the lower end $E_1 - G = aK_1^n$. Subtracting, $(E_m - E_1) = a(K_m^n - K_1^n) = h_m$, whence $K_m^n = \frac{h_m}{a} + K_1^n$. Substituting $\frac{Q}{h_m^{1/2}}$ for K_m, and transposing,

$$\frac{Q^n}{h_m^{\frac{n}{2}}} - \frac{h_m}{a} = K_1^n \qquad \text{[1]}$$

In a particular problem, if a and n can be evaluated, this equation can be plotted as a family of parabolas, using h_m as the parameter.

The K curve of Mr. Irwin's Fig. 1 appears to correspond to the specific equation: $E - 1{,}380.5 = 0.0072\ K^{0.64}$, in which $a = 0.0072$, $n = 0.64$, and $G = 1{,}380.5$. Equation 1 therefore becomes $\frac{Q^{0.64}}{h_m^{0.32}} - \frac{h_m}{0.0072} = K_1^{0.64}$. A portion of the plot of this equation is shown in Fig. 1 accompanying this discussion. In this figure, the value of h_m corresponding to a Q of 39,000 and a K_1 of 22,800 ±, is slightly over 1.3; actually, Mr. Irwin computes it to be 1.315.

In certain cases, the alternate method of solution presented here may be of value.

James B. Goodwin, M. Am. Soc. C.E.

Toronto, Canada
March 31, 1937

The Engineer and Highway Problems

To the Editor: In reading the various issues of Civil Engineering I have noted with interest several comments on highway problems in the department, "Our Readers Say." Since this department appears to offer a good means of getting our pet ideas off our chests, here are two such ideas on the subject for state highway departments.

In concrete road construction most of the expansion joints are placed perpendicular to the center-line of the road. The resulting "bump" is felt only slightly, of course, by passengers in an automobile. But since the joints are usually spaced an equal distance apart, the regularity of these bumps becomes annoying. If the joints were placed at an angle of 45 deg, or even at 60 deg from the center-line of the road, the bump would not be noticed as no two wheels would cross the joints together.

Turning now to the subject of safety in automobile driving, most highway departments are utilizing all the engineer's ability in trying to make the roads safe to drive upon. Even though all curves were spiraled and superelevated, there is still only one speed at which a vehicle can take a curve without having its rear wheels tracking either outside or inside the front ones. Such a condition may be serious when the road is wet. Would it not be possible to institute a campaign of roadside billboard propaganda, which would make the average driver realize that his responsibility to the public is much the same as that of the railroad engine man who must watch all the speed boards and curve markers and regulate the speed of his train accordingly? Highways would then carry markers recommending the proper speed at which to take each curve and thus eliminate some of the accidents caused by carelessness and a poor knowledge of the force of destruction the driver of a fast automobile has in his hands.

When accidents occur upon the roads, the criticism of the public invariably falls upon the engineer, so the problem of education is therefore his problem.

E. Staats Deakyne, Assoc. M. Am. Soc. C.E.

Salisbury, Md.
April 2, 1937

Question on Graphical Computation of Backwater Formulas

To the Editor: The method of eliminating the trial and error from backwater computations, described by R. L. Irwin, Jun. Am. Soc. C.E., in the March issue, is very interesting.

There is, however, one serious fault—not in method but in its application. The change of water surface elevation in any stretch of river is due to two factors, channel friction and change in velocity head. The latter factor is not included in the method presented. It is assumed that the changes in water-surface elevation may be represented by the Manning formula, which is a formula for hydraulic friction only.

J. C. Stevens, M. Am. Soc. C.E.
Consulting Engineer

Portland, Ore.
March 17, 1937

To the Editor: The error involved in neglecting the change in velocity head, as noted by Mr. Stevens, can be compensated by a correction factor, which can be included in the value of n. This may be a variable factor, and can be introduced in the K curve. Slope discharge measurements in stream gaging include this variation in n.

However, if the length of each reach is selected so that the cross-sectional area at the upper end is within 15 per cent of that at the lower, only a slight error would result in neglecting the change in velocity head. Even this error would probably be compensated in the following reach, since there is a tendency for the area to remain approximately constant for a given flow. The error would not, in any case, be cumulative in succeeding reaches. (Consideration should be given to the type of problem involved in applying the appropriate solution.)

I am accustomed to include the change in velocity head in the K curve of Fig. 1, which simplifies the solution and still gives quite accurate results.

In closing may I restate the following sentence from my article: "If very accurate results are required, the result given by the sliding scale can be used for the first approximation and refined by computation." I had hoped this would indicate sufficiently that the solution presented was not entirely correct. Practice permits quite reasonable approximations in many cases.

R. L. Irwin, Jun. Am. Soc. C.E.
U. S. Engineer Office

Huntington, W. Va.
March 26, 1937

SOCIETY AFFAIRS

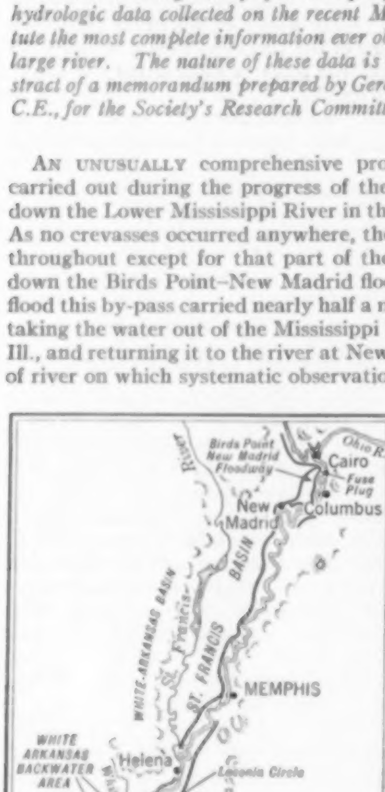
Official and Semi-Official

Observations Made on Mississippi River Flood of 1937

Thanks to the efficiency of the Corps of Engineers, U. S. Army, the hydrologic data collected on the recent Mississippi River flood constitute the most complete information ever obtained on any flood on a very large river. The nature of these data is indicated in the following abstract of a memorandum prepared by Gerard H. Matthes, M. Am. Soc. C.E., for the Society's Research Committee on Flood Protection Data. Its publication has been authorized by the Chief of Engineers, U.S.A.

A thorough discussion of the effects of recent channel improvements on the 1937 flood must await analysis of the data described here. That work is now in progress in the offices of the Mississippi River Commission, and as soon as accurate information is available, it will be presented by Mr. Matthes as a feature article in "Civil Engineering."

An unusually comprehensive program of observations was carried out during the progress of the record flood which passed down the Lower Mississippi River in the first three months of 1937. As no crevasses occurred anywhere, the flood waters were confined throughout except for that part of the flow which was by-passed down the Birds Point–New Madrid floodway. At the peak of the flood this by-pass carried nearly half a million cubic feet per second, taking the water out of the Mississippi River about opposite Cairo, Ill., and returning it to the river at New Madrid, Mo. The section of river on which systematic observations were made extends from Cairo to the mouth, a river distance of over 1,000 miles. In addition, observations were made in two floodways, on numerous tributaries, on the Atchafalaya River, and in backwater areas.



The Lower Mississippi River
Main Levees Shown with Heavy Lines

Gage Readings. There are 20 regularly maintained gages on the Mississippi River, averaging 50 miles apart. Ordinarily, these are read at 7 or 8 a.m. daily throughout the year. During the flood period, readings were taken with especial care, either to hundredths of a foot or to half-tenths, instead of to the nearest tenth of a foot as is the usual practice. On account of the strong winds that agitated the water surface, it became necessary to provide stilling boxes at a number of gages in order to make this plan workable. Commencing two days before the crest arrived, and continuing until two or three days after it had passed, these gages were read hourly day and night. The period covered by hourly readings at each gage averaged 15 days. These observations were made in order to develop the exact shape of the crest as it passed downstream, and to enable studies to be made of the rate of crest travel from gage to gage, a subject regarding which much remains to be learned.

In addition to the regular gages, 182 so-called high-water gages, averaging 5 miles apart, were read at intervals of two to three times a week, the readings being so taken as to make possible the construction of instantaneous water-surface profiles for use in hydraulic slope studies. To this number should be added 148 special gages established in the 12 cut-off channels. About 123 gages were read in the several backwater areas, which cover many thousands of square miles. This was done for the purpose of studying water-level fluctuations in connection with measurements of inflow to and outflow from these areas, which in a measure operate like natural retarding basins. Finally, about 60 gages on tributaries within the alluvial valley of the Lower Mississippi and in the Atchafalaya Basin were read once daily and sometimes oftener.

The great majority of the gages used in the Lower Mississippi Valley are staff gages of both vertical and inclined types. The unstable character of the bed and banks of the river, coupled with the great range between high and low stages (amounting to from 50 to 60 ft) renders the maintenance of self-registering gages impracticable at most points. There are only 6 self-registering gages in the area. Of these, 4 are operated by the U. S. Geological Survey; 3 are located on bridges across the main river at Memphis, Vicksburg, and New Orleans; and one is on the bridge at Krotz Springs across the Atchafalaya River. One self-registering gage at the head of Grand Lake and another at its foot, in the lower Atchafalaya Basin, are operated by the Army Engineers.

Levee Freeboard. Observations were made at frequent intervals along the levees to note the elevation of maximum stage, in order to establish the amount of remaining freeboard. These data, when plotted on the levee profiles, will furnish information essential for correcting established levee grades as may be necessary, and for determining how much larger floods the leveed channel is capable of handling.

Discharge Measurements were made at frequent intervals, in most cases daily, during the progress of the flood, at 13 main river stations and at 20 tributary stations. These are regular stations which are operated year after year. In addition, 14 special measuring ranges were established during the flood, most of them on the main river. Discharge measurements were also made of the flow through the 12 cut-off channels.

Of special interest are the discharge measurements made at the mouth of the St. Francis River, at the lower end of the White-Arkansas River backwater area, and at the southeastern end of the Red River backwater area, where Old River, an outlet of the Mississippi, interrupts the continuity of the levee system. These were needed to indicate the inflow into these areas from the Mississippi River during rising stages and the outflow during falling stages, thus affording means of determining the large volume of water, mounting into millions of acre-feet, that went into temporary storage in these natural flood-water reservoirs. In the case of the measuring range at the lower end of the White–Arkansas River backwater area, a large inflow from the Mississippi River was noted throughout the flood period, that is, during rising as well as falling stages. The inflow took place at the upper end of the range immediately adjacent to Laconia Circle, while the outflow occurred at a number of points farther downstream. The work done on this range, which is about 20 miles long, is exceptional in character. It furnishes information that has not heretofore been available in tangible form, and will go far towards clearing up the complex inflow-outflow conditions peculiar to this large backwater area, which in addition to water from the Mississippi, receives large

inflows from the Arkansas and White rivers. While these two rivers staged no spectacular floods on this occasion, their joint discharge nevertheless varied from 200,000 to 300,000 cu ft per sec—enough to represent a very material contribution.

Aerial Photographs. In addition to the hydrologic work, aerial photographs were taken of important stretches of river and of overflowed lands in backwater areas. This visual record will be of great value for future reference.

Floodways. The Birds Point–New Madrid floodway and the Bonnet Carré spillway were placed in operation for the first time since their completion, and received considerable attention. Numerous discharge measurements and gage observations were made on both; three measuring ranges were in operation on the former and two on the latter.

The flood records so procured will no doubt become of exceptional value to the engineers of the War Department concerned with the improvement of the river for navigation and with increasing its flood-carrying capacity. Previously the only flood of any magnitude which passed down the river, confined all the way, was that of 1929. It has served as a trustworthy reference, but its peak discharge between Cairo and Memphis was only about 1,600,000 cu ft per sec, and at Arkansas City less than 1,800,000 cu ft per sec. Furthermore, it represented the conditions that existed before the cut-offs were made and before the channel capacity was increased by dredging. The 1937 flood will probably serve as the criterion for guidance in planning future improvements for some time to come. Its discharge at Cairo and Memphis was in the neighborhood of 2,000,000 cu ft per sec and at Arkansas City 2,150,000 cu ft per sec. It came at a time when there were 12 cut-off channels in operation, which together with other improvements had lowered flood stages appreciably and consistently over a distance of 400 miles.

It will be many months before the data obtained will be ready for use in accurate studies. This is because it will be necessary to run check levels to all gages in order to correct for any settlement that may have taken place, and to check all computations of discharge measurements. In their present form, all data must be regarded as preliminary and subject to revision.

Except for three gaging stations operated by the U. S. Geological Survey on the main river and the Atchafalaya, all the observations here described were made under the direction of the Corps of Engineers, U. S. Army. The total number of discharge measurements made between January 26 and March 31 is not definitely known, but is in the neighborhood of one thousand.

In This Issue . . .

Spring Meeting at San Antonio

As this issue goes to press, members of the Society from all parts of the country are gathering in San Antonio for the Spring Meeting. The Texas Section has spared no pains to ensure its guests a fine program and a round of delightful entertainment in true southwestern style. In addition, the Meeting coincides with "Fiesta Week," a colorful Texas celebration that should provide added interest for all in attendance.

A full story of the Meeting, and abstracts of the papers presented at the seven technical sessions, will be published in forthcoming issues.

Civil Engineers on the Radio

For the last two months, fifteen-minute addresses by civil engineers have been a regular feature on the Tuesday afternoon schedule of radio station WNYC. The programs are arranged by the publicity department of the Society, and are designed to be of interest to a non-technical audience.

The series will continue through May and June. On the four Tuesdays in May the broadcast will be at 5:15 p.m., Eastern Standard Time. In June a later hour will be available, but remains to be set definitely. The listening radius of WNYC is conservatively estimated at 150 miles, and reports of "freak" reception have been received from points in states as far away as Texas. The population in the regular listening area is much in excess of ten million. The station operates at 810 kilocycles.

On May 4 the address will be given by Leslie G. Holleran, M. Am. Soc. C.E., on "Commuting—Present and Future for New Yorkers." Previous speakers (all members of the Society) and their subjects have included George T. Seabury, "The Civil Engineers' New York"; Harold M. Lewis, "New York Traffic—Present and Future"; Enoch R. Needles, "Construction Trends in New York City"; Admiral R. E. Bakenhus, "New York Harbor and the U. S. Navy"; Billings Wilson, "What Is the Port of New York Authority?"; Richard H. Gould, "How New York City Disposes of Sewage"; Miss Elsie Eaves, "Expenditures on Civil Engineering Projects in New York City"; Thaddeus Merriman, "Floods"; Lazarus White, "Deep Foundations for New York Structures." Copies of all these talks, aggregating more than 20,000 words, will be supplied to publicity committees of Local Sections, on request to Society Headquarters.

While on the subject of radio programs, mention should also be made of one that was broadcast early this year from station WEAN, featuring the engineering department of Rhode Island State College. Various professors and students, including the faculty adviser and several members of the Student Chapter, took part.

Mid-South Section's Annual Meeting Attracts 300 for Two-Day Program

Nearly 300 engineers registered for the eighth annual meeting of the Mid-South Section, which was held in Memphis, Tenn., on April 16 and 17, 1937. Approaching the scale of a convention, the meeting included inspection trips, a banquet, and other social events in addition to the regular sessions.

Discussions on Friday centered about regional planning, water resources, flood control, and economics. The principal speakers and their subjects were: E. S. Draper, "Regional Planning in the Tennessee Valley"; C. G. Paulsen, M. Am. Soc. C.E., "Investigation of the Nation's Water Supplies and Scope of Such Work in the South-Central States"; W. W. Horner, M. Am. Soc. C.E., "Relation of the Engineer to the Economic Phases of Engineering Projects"; Geo. R. Clemens, M. Am. Soc. C.E., "Old Man River Meets the 1937 Flood." An informal talk by L. F. Bellinger, Vice-President Am. Soc. C.E., concluded the technical sessions.

Special features of Friday's entertainment were a luncheon, held jointly with the Memphis Engineers' Club, and a banquet. Both functions were attended by more than 200 persons. The principal address at the banquet was given by Dr. Gus Dyer, on "Economic Aspects of Engineering Projects." Louis C. Hill, President Am. Soc. C.E., spoke informally. The program also included a variety of special entertainment numbers. Throughout the day, social events were provided for the visiting ladies.

Current construction projects in Memphis were described by Maj. Thomas H. Allen at the session on Saturday morning. Inspection trips in the afternoon brought the meeting to a close.

Section officers elected for the ensuing year are: Walter F. Schulz, president; W. D. Dickinson, vice-president; Blair Ross, secretary; W. W. Zass, director for Arkansas; Gerard H. Matthes, director at large. The territory of the Mid-South Section comprises parts of seven states: Missouri, Arkansas, Louisiana, Illinois, Kentucky, Tennessee and Mississippi.

Early Presidents of the Society

XIV. DON JUAN WHITTEMORE, 1830–1916

President of the Society, 1884

This is the fourteenth in a series of historical sketches—biographies of famous pioneers in American engineering. The next three articles will deal with Frederic Graff, Henry Flad, and William Ezra Worthen. Readers are invited to aid in the preparation of these articles by contributing pertinent photographs, facts, and anecdotes.

"THE HIGH OBJECT of our profession is to consider and determine the most economic use of time, power, and matter. In this we are gravely responsible... to that large, restless, and progressive portion of the civilized world which our organization assumes to represent. Upon the results of our industry and study largely depend the fortunes of a great people and the future of a continent...."

JON JUAN WHITTEMORE
Fourteenth President of the Society

Thus Don Juan Whittemore opened his address as President of the Society at its convention in 1884. But those same words, unexpressed, must long before have become the guiding concept of his life. For twenty years the growth and fortune of one of the country's largest railroad systems had depended largely on his economic use of time and power and matter; and through the development of that road the future of the northern Middle West was rapidly being molded.

In several ways the life of Whittemore closely parallels that of Charles Paine, whom he succeeded as President. Both were born in New England in 1830—Paine in New Hampshire, and Whittemore across the line in Vermont. Both got their early engineering training on the Vermont and Canada Railroad; both were division engineers on that line before their majority. While Paine was building docks at Montreal, Whittemore was also in Canada, as resident engineer on the Great Western Railroad between Niagara Falls and Windsor. Next, in 1853–1857, both were railroad pioneers in Wisconsin, Paine on the ill-starred Fox River valley lines and Whittemore as assistant to the chief engineer of the LaCrosse and Milwaukee Railroad Company. In 1863 the latter corporation, reorganized, became the Chicago, Milwaukee, and St. Paul, and Whittemore was made its first chief engineer. Within a year, Paine, moving to the other side of Lake Michigan, was chief engineer of the Michigan Southern.

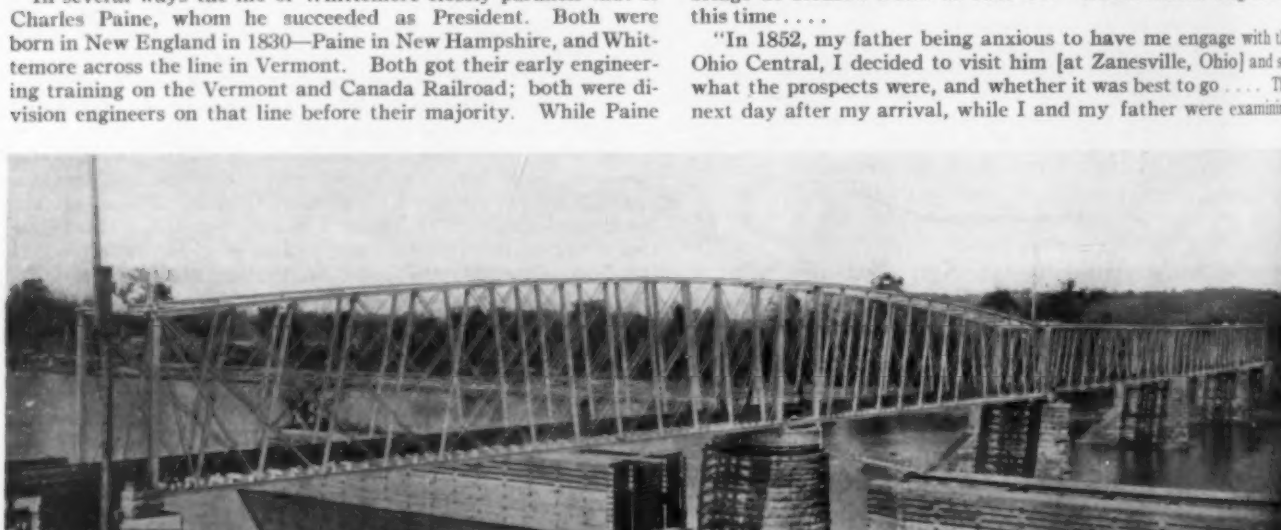
In following years, dissimilarities of the two men became apparent. Paine, more interested in promotion and management, engaged in a number of different enterprises, finally forsaking the railroads for work with the Westinghouse utilities and, later, private practice. Whittemore, less venturesome, and concerned somewhat more with things technical, took root in the Middle West, and remained with the Milwaukee as chief engineer for almost half a century.

For a brief sketch of Whittemore's life, no better outline is available than that dictated by himself in 1909 for family record. With a few unimportant omissions, it is reproduced here without change:

"I was born in Milton, Vermont, at a little hamlet called Checkerberry Green, December 6th, 1830. . . . My first school teachers were Sarah and Lovisa Wright (two giants in height, and mentally strong). Afterward one 'Nerrit,' an Irishman and a famous instructor, followed by one Johnson, a collegian, and Dr. F. B. Hathaway, also a superior teacher. At about 14 years of age my father placed me in school in St. Albans under the tuition of Friar Lawrence, so-called. I also spent a short term in Georgia School.... I then went to Bakersfield, where there was a celebrated school and teachers....

"Great credit is due my father for his home instruction, he being a natural student, linguist, lawyer and surveyor. He took great pains in the education, morals, and habits of his children. As I showed a fondness for mathematics and mechanics he secured me a position as surveyor on the Vermont and Canada R. R.... During this time the first trestle bridge ever built for railroads was erected on Missiquoi Bay between Alburg and Swanton, also a pontoon bridge at Rouse's Point in 1849–50. Was Division Engineer at this time....

"In 1852, my father being anxious to have me engage with the Ohio Central, I decided to visit him [at Zanesville, Ohio] and see what the prospects were, and whether it was best to go.... The next day after my arrival, while I and my father were examining



A CENTER-SWING BRIDGE OF 1872, ON THE C.M. AND ST.P. ROAD NEAR HASTINGS, MINN. (ACROSS THE MISSISSIPPI RIVER)
The Masonry and Piers Are Still in Service; the Last of the Steel Was Replaced in 1909

public works of Zanesville, by a fearful accident my father was deprived of his life, and I barely escaped the same fate. . . .

"I engaged with the Ohio Central Road leading from Wheeling, Virginia, to Columbus—over one hundred miles. My position there was contractor's engineer."

There followed the first Wisconsin engagement, already mentioned. Then:

"From 1857 to 1859 was Chief Engineer of the Southern Minnesota Railroad, running all over the State. This Company failed

Bridge Construction, 1880

The "Short Line" Bridge Over the Mississippi Between St. Paul and Minneapolis; Longest Truss Span, 324 Ft. The Structure Was Replaced in 1902

in 1860. . . ." On this engagement, it is interesting to note that Whittemore surveyed a line across the site of the present heart of the city of Minneapolis, and that not a single house or building was there to obstruct his work.

"In December, 1860, went to Cuba and engaged on the Ferro Carril del Oeste . . . as Asst. Chief. Road extended from Havana to Pinar del Rio . . . .

"Was married in Albany, New York; afterward went back West and became assistant to the Chief Engineer, W. R. Sill, of the LaCrosse and Milwaukee until 1863. Soon the Chicago, Milwaukee and St. Paul was organized, when I was appointed Chief Engineer . . . . Held this position 46 years [47 altogether; he did not retire until 1910].

"I conducted examinations through all the passes through the Rocky Mountains. About 300 men, 40 engineers. My present work—extension of the line to the Pacific Coast—the most important of all.

"On the St. Paul Road, east of Butte, Montana, are 107 miles of bridges, 12 tunnels, the longest $1^1/_2$ miles. My part of the work extends from the Missouri River to Butte, Montana, under the name of the Chicago, Milwaukee, and Puget Sound Railroad. I now have charge of about 9,000 miles of railroad. . . .

"In 1889, went to England to attend C.E. Convention as Past-President. Convention was held in London in Guildhall, a place where no other association had held exercises for 200 years. Responded to the toast: 'The Civil Engineers.' Met Tyndall, the scientist, and many other notables. . . . [A note by Whittemore's brother says that Tyndall "gave Don an invitation to bring his family to a luncheon at his home," and that "when they arrived he greeted them very cordially, even throwing his arms about Don, saying, 'This is my friend Whittemore.' "]

"On the 50th year of service on the St. Paul Railroad, to commemorate the event, I was, by order of the President, given a private car trip to Mexico and California with everything furnished, to which I invited my wife, and my brother's wife, son, and daughter. A very enjoyable trip without serious accident."

How casually Whittemore remarked that he had charge of "about 9,000 miles of railroad"! Had he been less modest he might have taken time to point out that that represented an average addition of 180 miles for each of his 50 years of service—more than half of it built under his supervision, and the rest, which had been acquired by purchase, largely rebuilt by his own organization.

In connection with one of these purchases, Whittemore once told the following story: In the very early days a bankrupt company applied to the president of Whittemore's corporation to become its purchaser. The line in question was wretchedly built, and the would-be purchaser, in attempting to secure a bargain, remarked, "We think from what you represent as the cost of this line that you did not exercise due economy in its building." The answer was promptly given: "The utmost economy was exercised. Why, we paid only $500 for engineering for the whole line of 36 miles." Says Whittemore:

"The line was purchased, and it became my duty to rebuild it from the grass roots up. During this process it was a constant puzzle to me to determine just where that $500 had been spent."

Though Whittemore was by nature more an "engineer" than an administrator, he was in no sense inadequate in the latter capacity. He understood the requirements of an engineering organization, and his ability to discern character enabled him to gather about him

Railroad Tunnels near Tomah, Wis.

The "New" Tunnel Was Built in 1875; the Earlier One (to the Left) Dates from 1858

efficient and loyal assistants and to employ competent contractors. He had, to a high degree, the quality of winning the respect and loyalty of his associates.

He was able to collaborate with those who had made particular study of special problems and to learn and apply the knowledge acquired by their intensive experience, to their mutual satisfaction. This was especially the case in the matter of bridges. With the aid of such men as C. Shaler Smith and Moritz Lassig, Members Am. Soc. C.E., he provided for his lines structures of such character as to make them noted examples of correct and bold construction.

His specifications for the Kilbourn and Rockton bridges (1877) were so thorough that they were largely circulated and copied from by other engineers both in this country and abroad. They have been described as "classics in their line, leading the art of the time in form, completeness, and correctness of theory and design."

Whittemore's career is the more remarkable for the fact that he was physically not very rugged, and had to depend largely on others for field reports. But a "photographic mind" made up for this deficiency. It is said that he could get a clearer picture of conditions from maps and reports than an ordinary man would get from actual observation. In 1910 he made a trip over the Puget Sound extension, and along the route, while watching out the window, he called attention to place after place where various difficulties had occurred during the construction. Yet it was his first visit to the site; he recognized the spots solely from his familiarity with the maps in his office.

Whittemore was interested in a number of lines of research, and in his leisure loved to ponder over abstruse problems that were only remotely connected with his usual practice. The ideal engineer, he once said, is by necessity "concerned in a knowledge of all the sciences, and by an equal necessity he is dependent upon an intimate knowledge of all the abstruse principles of science. It is his duty both to create and apply knowledge."

He gave much attention to the production of aluminum at a pe-

riod antedating its manufacture on a commercial scale, and though successful in extracting it, did not reach the achievement obtained by the method at present in use. He also invented a number of devices, among them an "equilibristat"—an instrument to be mounted in a railroad car to indicate whether the superelevation of curves was proper for the speed of the car passing over them. Another invention was a press and flask for molding cement tension-test briquettes.

He made little attempt to capitalize on any of his inventions; his attitude in this regard was typified by the concluding sentence of his description of the briquette-molder: "Believing that any instrument devised for purely scientific purposes should never be patented, I freely offer the design to all who may now or hereafter desire to make use of it."

In the early 1870's, portland cement had not yet come on the American market in appreciable quantities. The demand for natural hydraulic cements, however, was increasing constantly, and the district around Louisville, Ky., was supplying the product to points as distant as Ontario and Florida. It happened that a Milwaukee manufacturer of sewer pipe, J. R. Berthelet, was using the Louisville cement, and having made frequent visits to the quarries and mills, was familiar with the appearance of natural cement rock and with the method of manufacture. One day in the office of the Milwaukee city engineer he noticed some samples of rock that had been taken from the excavation for a municipal bridge. His curiosity was aroused by their resemblance to the Louisville rock, so he took them home, calcined them in the cookstove, reduced them to powder, and mixed up a mortar. It worked.

Berthelet interested a number of friends in his discovery, among them Whittemore. The latter immediately undertook an exhaustive set of experiments to determine the uniformity of the natural material and the strength of the product. He manufactured his cement "by hand," reducing the calcined rock to powder with mortar and pestle and passing it through a fine sieve. The preliminary tests being so satisfactory, he cast about to find recorded experimental tests of the strength of commercial cements already on the market, with which to compare his own product. But not one of the western cements that were so extensively used in the vicinity had ever been tested!

Whittemore therefore continued his tests, using 16 different commercial brands as well as samples of the local product. He determined their tensile, breaking, crushing, and adhesive strengths, and in each case the local cement showed an average strength greater than the maximum of any of the commercial brands. As a result of these findings, the Milwaukee Cement Company was formed—probably the first such organization that had a thorough scientific knowledge of its product. Near the close of the century it was producing almost 6 per cent of all the natural cement manufactured in the country.

When portland cement began to compete with the natural product, Whittemore entered that field also, becoming vice-president in 1889 of the Western Portland Cement Company, whose plant was near Yankton, S.Dak. This was one of the few concerns that used chalk and clay as the raw materials.

Despite these ventures into commercial fields, Whittemore always considered the interest of his employer as his first and principal duty. As a consequence he did not participate to any great extent in employment as a consulting engineer, though the writer of his Memoir remarks that he might have done much more of such work "without detriment to his employer and to the advantage of the profession."

Whittemore retired from his position as chief engineer of the Milwaukee lines on his eightieth birthday, December 6, 1910, and died on July 16, 1916. He was an honorary member both of the American Society of Civil Engineers and of the Western Society of Engineers.

[The cooperation of R. J. Middleton, Assoc. M. Am. Soc. C.E., who secured the illustrations used in this article, is gratefully acknowledged. The pictures are the property of the Milwaukee Road Museum.]

Central Illinois Section Backs Registration Bill

THE Central Illinois Section is actively supporting the proposed revision of the Illinois registration law that is now before the state legislature. For 18 years Illinois has had a registration law for structural engineers, and the current proposal has for its object the broadening of its provisions to cover all other practicing professional engineers. The present legal status of the structural engineer in relation to the practice of architecture would be retained, and those registering as professional engineers would have to qualify in addition as structural engineers to be certified in the latter capacity.

By unanimous vote the Section on March 12, 1937, adopted a resolution endorsing the bill. With similar resolutions from other engineering organizations, it was placed in the hands of the "general committee on registration of engineers in Illinois" for presentation at the legislative hearing. The general committee is not affiliated with any society or group of organizations, but is representative of all practicing engineers throughout the state. Its chairman is Jacob A. Harman, M. Am. Soc C.E.

Special Reprint of Articles on Life of Thomas Telford

THE four articles on the life and works of Thomas Telford, by John F. Baker, Assoc. M. Am. Soc. C.E., and John Armitage, which have appeared in CIVIL ENGINEERING, are being published together in the form of a 24-page reprint. Because of the wide interest shown in this series, a number of extra copies have been ordered, to be made available to members at a cost of 35 cents apiece, upon application to Society Headquarters. The individual articles appeared in CIVIL ENGINEERING for November and December 1936, and for February and April 1937, respectively.

Student Chapters in Virginia Hold Regional Convention

ON MARCH 27, 1937, the third annual Virginia Regional Student Convention was held at the University of Virginia. Some 75 members of the Student Chapters at Virginia Military Institute and Virginia Polytechnic Institute attended as guests of the local Chapter.

At the morning session addresses were given by John L. Newcomb, E. M. Hastings, and Col. D. H. Sawyer, all members Am. Soc. C.E., and Dean W. S. Rodman. The afternoon program included four student papers and a lively round-table conference. Subjects of discussion were (1) the five-year engineering course, (2) the relative merits of specialized and general engineering courses, and (3) the most satisfactory type of program for a student convention. Social features of the convention included a luncheon and a tea dance.

"Aims and Activities" Mailed

DURING the last week of April, there was mailed to each member of the Society a copy of the 1937 edition of the booklet, *Aims and Activities*. In its pages will be found, in convenient form, many valuable facts about the organization and achievements of the Society, based upon the information in the Year Book, but with certain features not included in the larger publication.

Of special interest is the map which shows the location of each Student Chapter, and the headquarters of each Local Section of the Society, brought up to date as of April 1, 1937. A new map of New York City is also presented, prepared especially to show the central location of Society Headquarters, in the Engineering Societies Building. The portraits of all officers, and members of the Board of Direction for the current year have been assembled on two pages.

If you wish to have an extra copy of the booklet, to give to a prospective member of the Society, it will be gladly sent on request to Headquarters, 33 West 39th Street, New York, N.Y.

Employment in the Engineering Profession, 1929 to 1934

Third Release of Data from Survey of the Engineering Profession Conducted by the U. S. Bureau of Labor Statistics

The third article of the series reporting the analysis of the returns from a Survey of the Engineering Profession appeared in the April issue of the "Monthly Labor Review," published by the federal Bureau of Labor Statistics. It was prepared by Andrew Fraser, Jr., of the Bureau's Division of Wages, Hours, and Working Conditions. The following abstract and excerpts from that article comprise all of the tabular material and about 60 per cent of the text. Similar résumés of the first two articles, concerned respectively with the education of the engineer and unemployment in the engineering profession, appeared in the August 1936 and February 1937 issues of "Civil Engineering." Other articles will follow as released by the Bureau.

ANALYSIS has been made by the Bureau of Labor Statistics of reports from 52,589 engineers, showing the kinds of employment engaged in at specified periods. The study was undertaken in May 1935, at the request of the American Engineering Council. The following general findings were established by this analysis:

Over the 5-year period ending December 1934, the number of persons in the engineering profession increased by 25.3 per cent. This rate of increase was much in excess of available engineering employment opportunities.

The growth among the several professional classes over the period 1930–1934 ranged from 17.6 per cent for mining and metallurgical to 62.5 per cent in the case of chemical and ceramic engineers.

The lack of opportunities for engineering employment differed markedly among the professional classes. Thus, over the 5-year period, and for the profession as a whole, private engineering employment declined by 8.2 per cent, though it increased by more than a third for chemical and ceramic engineers, and decreased about one-third for civil engineers.

TABLE I. DISTRIBUTION OF ALL ENGINEERS REPORTING, BY EMPLOYMENT STATUS AT END OF 1929, 1932, AND 1934
(Adjusted Figures)

EMPLOYMENT STATUS	NUMBER			PER CENT			INCREASE OR DECREASE IN NUMBER		
	1929	1932	1934	1929	1932	1934	1929 to 1932	1932 to 1934	1929 to 1934
Grand total, United States	31,252	35,691	39,161	100.0	100.0	100.0	+4,439	+3,470	+7,909
Engineering employment	29,051	27,787	30,299	93.0	77.9	77.4	−1,264	+2,512	+1,248
Private[1]	22,456	19,797	20,619	71.9	55.5	52.7	−2,659	+ 822	−1,837
Public[2]	6,595	7,990	9,680	21.1	22.4	24.7	+1,395	+1,690	+3,085
Non-engineering employment	1,969	4,290	5,523	6.3	12.0	14.1	+2,321	+1,233	+3,554
Unemployment	232	3,614	3,339	0.7	10.1	8.5	+3,382	− 275	+3,107

[1] Includes those engineers in the employ of private firms, independent consultants reporting "any other employment," and teaching.

[2] Includes those engineers in the employ of federal, state, county, municipal governments, and other public authority.

All professional classes participated in the increases in employment of engineers by public authorities. The civil engineers were most affected. The proportion of this group employed by public authorities increased from 40.0 per cent in 1929 to 48.5 in 1934.

In 1929 private engineering furnished by far the greatest employment for engineers. For civil engineers this covered 54.3 per cent. By December 1932, private engineering among civil engineers had dropped to 37.6 per cent and by December 1934 to 31.8 per cent. There was also a continuous decline in this type of employment among electrical engineers, during the 5-year period. For the remaining professional classes, however, there was a slight improvement in 1934 over 1932.

Non-engineering employment increased sharply from 1929 to 1932 and in equal measure for all professional classes, absorbing many more engineers than did public engineering. But there was an even larger increase in unemployment in all professional classes. Between December 1932 and December 1934 there were further increases in non-engineering employment for all professional classes, though not so great as between 1929 and 1932. Unemployment declined for all professional classes, except for civil engineers.

The sharpest increases in public engineering employment occurred in the period 1932–1934.

Of all engineers who reported as being professionally active prior to 1930, only 46.2 per cent were in the employ of private firms in 1934; in 1929, 62.2 per cent were so engaged. Federal government employment provided for 10.1 per cent in December 1934; in 1929, this field gave employment to only 5.3 per cent.

Over the period 1930–1934 there was a remarkable stability in those engineers classified as independent consultants, or engaged in the teaching of engineering subjects. This was also the case for those in the employ of state, county, municipal, and other public authorities.

The net new private-firm employment that developed between 1930 and 1934 was secured by newcomers who entered the profession in this period. The increase in public engineering employment was shared by both older and younger engineers.

SCOPE AND METHOD OF STUDY

The primary objectives of this analysis were to determine what kinds of engineering employment were most stable, and what types of substitute employment engineers found during the depression years.

The engineer was requested to check his employment status against only 1 of 14 items for each of the 3 years ending December 31, 1929, 1932, and 1934. In analysis, these 14 categories were reduced to 8 and are in this article designated thus: (1) Private firm,[1] (2) independent consultant, (3) teaching, (4) federal, (5) state and county, (6) municipal and other public authority, (7) non-engineering employment, (8) total unemployment.[2] In the ensuing discussion, items (1) to (3) inclusive, and (4) to (6) inclusive are hereafter referred to, respectively, as private engineering employment and public engineering employment, and these two in combination as total engineering employment.

EMPLOYMENT STATUS OF ENGINEERS, 1929–1934

During the period 1930 to 1934, inclusive, the total number of engineers seeking employment was increased by almost 10,000 per year, largely through the addition of new college graduates. Thirty-two per cent of these recent college graduates returned their questionnaires, in contrast to 15 per cent of those who were actively engaged in the profession prior to 1930. This disparity necessitated adjusting the sample to obtain the over-all distributions of employment status for 1932 and 1934. This adjustment was possible because for separate age groups among both the younger and older engineers the percentage of replies shows homogeneous sampling within these two groups.

These distributions for the years 1929, 1932, and 1934 are presented in Table I for the profession as a whole.

This increase took place during 5 years of depression in which available engineering opportunities were insufficient to absorb the supply of engineers. The percentage of those reporting unemployment declined from 10.1 at the end of 1932 to 8.5 at the end of 1934, but in the face of the continuing influx of engineers, the absolute number of those unemployed declined only slightly in that period. Furthermore, while the presence of 6.3 per cent of the professional engineers in non-engineering employment in 1929 indicates this was even then an established and normal outlet for them, there was an enormous increase in such work between 1929 and 1932. There

[1] Includes also those reporting as employees of private consulting firms and under "any other employment" in Question 6.

[2] Includes also those reporting work relief and direct relief.

TABLE II. EMPLOYMENT STATUS AT END OF 1929, 1932, AND 1934 OF ALL ENGINEERS REPORTING, BY PROFESSIONAL CLASS
(Adjusted Figures)

Professional Class	Number of Engineers: Total			In Engineering Employment: Total Private[1]			In Engineering Employment: Total public[2]			In Non-Engineering Employment			Unemployed[3]		
	1929	1932	1934	1929	1932	1934	1929	1932	1934	1929	1932	1934	1929	1932	1934
Total, United States	31,252	35,691	39,161	22,456	19,797	20,619	6,595	7,990	9,680	1,969	4,290	5,523	232	3,614	3,33[illegible]
Chemical and ceramic	1,470	1,931	2,389	1,217	1,322	1,640	103	122	143	143	320	459	7	167	147
Civil, agricultural, and architectural	13,786	15,330	16,365	7,477	5,760	5,191	5,510	6,620	7,941	694	1,413	1,556	105	1,537	1,677
Electrical	6,112	7,276	8,117	5,238	4,940	5,137	350	456	623	493	1,155	1,759	31	725	598
Mechanical and industrial	8,455	9,587	10,609	7,374	6,729	7,512	504	643	802	517	1,190	1,518	60	1,025	777
Mining and metallurgical	1,429	1,567	1,681	1,150	1,046	1,139	128	149	171	122	212	231	20	160	140

[1] Includes employees of private firms, independent consultants, "any other employment," and teaching.
[2] Includes federal, state, county, and municipal governments, and other public authority.
[3] Includes direct relief and work relief.

was a further, but smaller, increase in non-engineering work between 1932 and 1934. There is reason to believe, from a preliminary examination of income data, that the specific non-engineering work of many of those reporting was much more frequently of a makeshift character in 1934 than in 1929.

Engineering employment as a whole declined 4.4 per cent between 1929 and 1932. There was a rise by December 1934, due primarily to the increases in the public employment of engineers. Private employment decreased by 11.8 per cent from 1929 to 1932, and was still 8.2 per cent below the 1929 level at the end of the 5-year period.

The dependence upon public employment is further evidenced by the fact that although both classes of engineering employment increased between December 1932 and December 1934, the absolute increase reported in private employment was only half of that in public employment. Relative to the numbers so employed in 1932, the rate of increase in public employment was almost five times as great as that in private employment.

The preceding analysis was concerned only with the engineering profession as a whole. Corresponding data for each professional class are presented on an adjusted basis in Table II.

TABLE III. PERCENTAGE OF CHANGE IN ENGINEERING EMPLOYMENT, BY PROFESSIONAL CLASS, 1929 TO 1934
(Adjusted Figures)

Professional Class	Per Cent Increase in Each Professional Class, 1929–1934	Per Cent of Increase or Decrease, 1929–1934, in: Total Engineering Employment	Private[1] Engineering Employment	Public[2] Engineering Employment
Total, United States	+25.3	+4.4	−8.2	+46.8
Mining and metallurgical	+17.6	+2.5	−1.0	+33.6
Civil, agricultural, and architectural	+18.7	+1.1	−30.6	+44.1
Mechanical and industrial	+25.5	+5.5	+1.9	+59.1
Electrical	+32.8	+3.1	−1.9	+78.0
Chemical and ceramic	+62.5	+35.1	+34.8	+38.8

[1] Includes employees of private firms, independent consultants, "any other employment," and teaching.
[2] Includes employees of federal, state, county, and municipal governments and other public authority.

In no professional class did total engineering employment keep pace with the growing number of engineers (Table III). Roughly, one-fifth of the total increase in number of all engineers between 1930 and 1934 was provided for by the growth of new jobs.

The data for private and public engineering in Table III accentuate the differences in available engineering opportunities for each professional class. Thus, over the 5-year period, and for the profession as a whole, although private engineering employment declined by 8.2 per cent, it increased by more than a third for chemical and ceramic engineers. There was little increase or decrease for electrical, mining and metallurgical, and mechanical and industrial engineers; but in the case of the civil engineers, there was a decrease of about one-third in private engineering employment. By contrast no professional class was excepted from the increases which took place in public engineering employment. The civil engineers were most affected. For them public employment was an important field in 1929, when 40 per cent of all civil engineers were so engaged. The 44.1 per cent increase by 1934 in the amount of such employment reported meant an absolute increase of 2,431 jobs over the 5-year period.

Changes in the proportions, first, of those engaged in engineering, and second, of those unemployed, or engaged in non-engineering work, are shown in Table IV.

Private engineering employment furnishes by far the greatest amount of employment to engineers. However, the proportions dropped sharply from 1929 to 1932 because of a decrease in the number of private jobs and an increase in the number of engineers. By the end of 1934, there was a further decrease in the proportion privately employed among both civil and electrical engineers, the former decreasing to 31.8 per cent. There was a slight improvement over 1932 for the remaining classes.

In all classes but one the proportions engaged in public engineering increased from 1929 to 1934. The most pronounced shift occurred among the civil engineers, and this in some measure compensated for the large decline in the private engineering employment of this class. Indeed, as a result of public employment, the proportion of civil engineers in total engineering employment in both 1932 and 1934 was slightly higher than in any other professional class.

Lack of engineering employment opportunities in the period 1929–1932 led to increases in both non-engineering employment and unemployment for all professional classes. In general, the loss of private employment occurred from 1929 to 1932. Non-engineering employment increased sharply, absorbing many more engineers than public engineering work, in which employment also increased. But there was an even larger increase in unemployment.

There were further increases in the proportions engaged in non-engineering work among all professional classes in the period 1932–1934, but in the case of civil engineers and mining and metallurgical engineers, they were almost negligible. For each of these groups there was a greater increase from 1932 to 1934 in public than in non-engineering employment, and for civil engineers it was much larger.

EMPLOYMENT STATUS IN COMPARABLE AGE GROUPS

Comparison of the distribution of employment in 1929 of all engineers who entered the profession in the period 1925–1929, with that in 1934 of a comparable group who entered the profession between 1930 and 1934, reflects the pressures to which new entrants were subjected during the depression years. It also emphasizes the abnormality of the employment status of the latter in 1934.

In 1929 all but one-twentieth of those who entered the profession in the preceding 5 years were employed in engineering work (Table V). But in 1934, two-fifths of the comparable group of recent engineering graduates[3] were either unemployed or engaged in non-engineering work.

Of all recent engineers, both in 1929 and in 1934, approximately one-fifth were engaged in the three categories of public engineering. In so far as any differences existed, there appears to have been a slight decline in the proportions of the 1930–1934 group that secured public employment. However, the federal government employed a larger percentage of the recent graduates in 1934 than it had employed in 1929.

[3] The term "engineering graduate" is used interchangeably with "entered the profession." The tabulations cover predominantly those who received first degrees in engineering in the years specified, but also include all "other" engineers (such as those whose college work was incomplete) who were 23 to 27 years old at the date of reported employment.

TABLE IV. PERCENTAGE DISTRIBUTION OF ENGINEERS REPORTING, BY EMPLOYMENT STATUS AND PROFESSIONAL CLASS, AT END OF 1929, 1932, AND 1934
(Adjusted Figures)

Professional Class	Per Cent of Total in Each Professional Class Reporting											
	Engineering Employment						Non-Engineering Employment			Unemployment[3]		
	Private[1]			Public[2]								
	1929	1932	1934	1929	1932	1934	1929	1932	1934	1929	1932	1934
Total, United States	71.9	55.5	52.7	21.1	22.4	24.7	6.3	12.0	14.1	0.7	10.1	8.5
Chemical and ceramic	82.8	68.5	68.7	7.0	6.3	5.9	9.7	16.6	19.2	0.5	8.6	6.2
Civil, agricultural, and architectural	54.3	37.6	31.8	40.0	43.2	48.5	5.0	9.2	9.5	0.7	10.0	10.2
Electrical	85.6	67.8	63.1	5.8	6.3	7.8	8.1	15.9	21.7	0.5	10.0	7.4
Mechanical and industrial	87.3	70.2	70.8	5.9	6.7	7.6	6.1	12.4	14.3	0.7	10.7	7.3
Mining and metallurgical	80.6	66.8	67.9	8.9	9.5	10.1	8.5	13.5	13.7	2.0	10.2	8.3

[1] Includes employees of private firms, independent consultants, "any other employment," and teaching.
[2] Includes employees of federal, state, county and municipal governments, and other public authority.
[3] Includes direct relief and work relief.

In 1929 nearly three-fourths of the recent engineers were in private engineering employment. Only 40.9 per cent of the 1930–1934 engineers so reported for December 1934. Clearly, the abnormally large proportion of the new entrants who were unemployed or in non-engineering work in 1934 was due primarily to the lack of opportunities in the principal field of engineering activity. An important contributory factor was that the number of those graduated from engineering courses in colleges was about 20 per cent higher from 1930–1934 than from 1925–1929. In numbers, this increase was about 10,000 individuals.

This dependence upon private engineering employment is common to the greater part of the engineering profession. A substantial number, however, are normally in the employ of public authorities. This is borne out by considering the distributions of employment status of all engineers reporting (Table VI).[4]

Over the five-year period there was a net change in the distributions of employment affecting 16.8 per cent of the "older" engineers; that is, of engineers who had entered the profession prior to 1930. No less than 5,002 of the "older" engineers reporting were separated from private firms during that time. The remaining net losses of employment were distributed among those engaged in independent consulting (60), in teaching (16), and in municipal and other public employment (177). These decreases were not counterbalanced by increases in the other classes of engineering employment. In fact, 2,270 engineers reporting graduation prior to 1930 were still unemployed in December 1934, while 1,233 found employment in non-engineering work. Only 1,752 had been absorbed by increases in public engineering employment, five-sixths of them with the federal government.

The major part of the loss of employment for older engineers occurred from 1929 to 1932. In this period net shifts in employment had affected the status of 14.7 per cent of these men. The net change in the period 1932–1934 involved only 4.0 per cent of them. Between December 1929 and December 1932 there were net losses of employment involving 4,608 engineers. Only two of the categories of employment were involved—private firms, and municipal and other public authorities. But the shrinkage of employment with private firms affected 4,530; the latter, only 78. Of these engineers, only 884 were able to find other types of engineering employment by December 1932; nearly 50 per cent of them entered federal government employment, while a third entered state and county employment. There were 156 additional engineers reporting themselves as independent consultants and 60 as engaged in teaching. Of the remaining 3,724 engineers, 2,646 were unemployed and 1,078 were engaged in work of a non-engineering nature.

The shifts noted in the period 1929–1932 are indicative of two trends affecting engineers who had been in the profession in 1929: (1) The pronounced increase in federal employment and the decrease in private-firm employment; and (2) the comparative stability of the remaining classes of engineering employment. These trends are further accentuated in the shifts between 1932 and 1934.

In 1932–1934, all categories of engineering employment, with the exception of that with the federal government, decreased. Thus, an additional net total of 472 engineers graduating before 1930 were separated from private firms. The decreases in jobs in the remaining engineering classes ranged from 2 in the case of teaching to 216 for independent consultants. It would seem that the increase in the latter group in 1932 was an artificial one. Altogether, the decreases in engineering employment affected 865 engineers. Nevertheless, there was also a decrease of 376 in the number of engineers reporting unemployment. Only 155 found opportunities in non-engineering employment. The federal government gave engineering employment to the remaining 1,086 (87.5 per cent) of those whose status shifted from 1932 to 1934.

The net result of the changes in employment status among the older engineers was such that by December 1934 only 46.2 per cent were in the employ of private firms, whereas 62.2 per cent had been so engaged at the end of 1929. Federal employment provided for 10.1 per cent in December 1934, as against only 5.3 per cent in 1929. All other classes of engineering employment remained comparatively stable over the period. In December 1934 there were 8.0 per cent unemployed, but it is obvious that had not 10.2 per cent of the older engineers found work of a non-engineering nature, the proportion unemployed would have been larger by that amount. It is also obvious that it was primarily the increased employment by the federal government that ameliorated conditions for these older engineers.

Among the engineers who entered the profession during the depression, certain outstanding shifts may be noted. In the first place employment opportunities increased from the end of 1932 to the end of 1934 among those who graduated in 1930–1932. Slightly more than half of the 16.6 per cent of this group who had been unemployed or on work relief in 1932 found employment by 1934. Furthermore, they had found non-relief engineering employment. The gain was almost equally divided between private

TABLE V. COMPARATIVE EMPLOYMENT STATUS OF TWO GROUPS OF YOUNGER ENGINEERS

Age Group	Number of Engineers						
	Total	In Private[1] Engineering Employment	In Public Engineering Employment			In Non-Engineering Employment	Unemployed[2]
			Federal	State and County	Municipal and Other Public Authority		
1925–29 engineers, who were 23 to 27 years of age in 1929	6,997	5,151	452	618	375	371	30
1930–34 engineers, who were 23 to 27 years of age in 1934	16,872	6,910	1,544	1,272	401	4,959	1,786
	Per Cent						
1925–29 engineers, who were 23 to 27 years of age in 1929	100.0	73.6	6.5	8.8	5.4	5.3	0.4
1930–34 engineers, who were 23 to 27 years of age in 1934	100.0	40.9	9.2	7.5	2.4	29.4	10.6

[1] Includes employees of private firms, independent consultants, "any other employment," and teaching.
[2] Includes work relief and direct relief.

[4] Table VI presents the absolute figures for all reports received without adjustment. It deals with the older and younger engineers separately, and therefore no adjustment was required in these broad age classifications.

Older engineers comprise all those who were active in professional engineering prior to 1930. The younger engineers are those who entered the profession in the years 1930–1934, inclusive, and are divided into two broad-age groups, each designated by the graduating classes which they embrace, namely, 1930–1932 engineers and 1933–1934 engineers. Furthermore, in tabulating the data on employment status, homogeneity of the older and 1930–1932 engineers was maintained. That is, in the case of the former, only those reporting for the three years 1929, 1932, and 1934 were used; in the case of the latter, only those reporting for the two years 1932 and 1934 were included. Analysis shows that the percentage eliminated was small.

TABLE VI. DISTRIBUTION OF OLDER AND YOUNGER ENGINEERS REPORTING, BY EMPLOYMENT STATUS, AT END OF 1929, 1932, AND 1934

EMPLOYMENT STATUS	NUMBER						PER CENT					
	Older Engineers[1]			Younger Engineers			Older Engineers[1]			Younger Engineers		
				1930–1932[2]		1933–1934[3]				1930–1932[2]		1933–1934[3]
	1929	1932	1934	1932	1934	1934	1929	1932	1934	1932	1934	1934
Grand total, U. S. . .	31,252	31,252	31,252	9,469	9,469	7,403	100.0	100.0	100.0	100.0	100.0	100.0
Engineering employment	29,051	25,327	25,548	5,248	6,057	4,070	93.0	81.1	81.8	55.4	64.0	55.0
Private employment .	22,456	18,142	17,378	3,532	3,926	2,984	71.9	58.1	55.7	37.3	41.5	40.4
Private firm . . .	19,424	14,894	14,422	3,247	3,748	2,892	62.2	47.7	46.2	34.3	39.6	39.2
Independent consultant	1,303	1,459	1,243	50	25	17	4.2	4.7	4.0	0.5	0.3	0.2
Teaching	1,729	1,789	1,713	235	153	75	5.5	5.7	5.5	2.5	1.6	1.0
Public employment .	6,595	7,185	8,170	1,716	2,131	1,086	21.1	23.0	26.1	18.1	22.5	14.6
Federal	1,647	2,063	3,149	531	1,008	536	5.3	6.6	10.1	5.6	10.6	7.2
State and county .	2,632	2,884	2,882	927	872	400	8.4	9.2	9.2	9.8	9.2	5.4
Municipal and other public authority . . .	2,316	2,238	2,139	258	251	150	7.4	7.2	6.8	2.7	2.7	2.0
Non-engineering employment	1,969	3,047	3,202	2,651	2,655	2,304	6.3	9.7	10.2	28.0	28.0	31.1
Unemployment . . .	232	2,878	2,502	1,570	757	1,029	0.7	9.2	8.0	16.6	8.0	13.9

[1] Includes both graduates and "other" engineers who were professionally active prior to 1930.
[2] Includes both graduates and "other" engineers who entered the profession in the years 1930–1932.
[3] Includes both graduates and "other" engineers who entered the profession in the years 1933 and 1934.

employment and public employment. The increase in employment by private firms absorbed 5.3 per cent of all engineers in these classes. The slight decline in the proportions employed by states and counties was much more than offset by an expansion of federal employment.

While recent graduates in 1934 had as much opportunity for engineering employment as a comparable group had had in 1932, this was because of an expansion in private employment and particularly employment with private firms. The total opportunities for public employment were less in 1934 among the most recent graduates than had been true of a similar group in 1932. The federal government did employ 1.6 per cent more of them in 1934, but this could not offset the decline of employment opportunities with states, counties, and municipal authorities.

The preceding discussion has shown the barriers that the depression threw in the way of newcomers to the profession. It now remains to examine the effect that even the partial absorption of the newcomers had upon the employment opportunities of the older engineers.

This interrelationship is best studied in two different phases of the employment cycle: (1) During a period of an absolute contraction in job opportunities, and (2) during a period of expansion. These conditions are represented respectively by the two periods 1929–1932 and 1932–1934. The adjusted data are presented in Table VII.

By December 1932 employment with private firms had declined by 15.5 per cent. The loss of employment by private firms among older engineers was even greater than this. Yet, even at this period no less than 1,522 of those engineers who entered the profession in the period 1930–1932 found engineering employment with private companies. Thus, approximately two-thirds of the loss of employment among older engineers was due to a decrease in the total amount of private employment available, while one-third was due to the fact that older engineers were unable or unwilling to take employment which the newcomers secured.

By the end of the second period, private firm employment increased by 6.8 per cent over that reported for December 1932. Yet, even in this period there was a reduction in employment with private companies that affected 472 of the older engineers. Essentially, therefore, those who entered the profession in the years 1930–1934 secured all the net new employment that developed with private firms and also continued to find some openings at the expense of the older engineers. Over the entire five-year period 1930–1934, although 5,002 older engineers suffered loss of employment with private firms, no less than 3,112 of the new entrants found engineering work.

This was probably not the result of a direct displacement on a particular job of any one group of older by younger engineers. The explanation is to be found in the relative ease with which a younger engineer found a new job; the older engineer inevitably had a greater concern with the suitability of the employment and remuneration than had the man without an established position. The changes effected by the depression upon engineers in the employ of state, county, municipal, and other public authorities, are in striking contrast to those which occurred among older engineers in private firms. Between 1929 and 1932 there was a 14.7 per cent increase over the total of 4,948 who were engaged by public authorities in 1929. The increase was shared by both the older engineers and new entrants. The number of the former increased by 174, the latter by 555. By December 1934 the total so employed had increased to 5,804. But in this second period the new entrants increased by 228, whereas the older engineers decreased by 101.

This decrease may not have been due wholly to the increase of new entrants. Many of the older engineers may have found this employment an easier passage to federal employment, which, in the period 1932–1934, required a large number of engineers as administrators and supervisors—positions that may have been more in keeping with the older engineers' previous training and experience.

This last statement is substantiated by the changes which occurred in federal employment. In both periods the absolute number of older engineers who found this kind of work was greater than that for the younger engineers.

Over the five-year period the younger engineers had a decided advantage in securing non-engineering employment. Thus, 15 per cent of the displaced engineers who were over 52 years old in 1934 secured non-engineering work; the remainder were unemployed. Among those who were 28 to 32 years of age, 52 per cent of those displaced secured non-engineering employment. The percentage was even higher among those still younger, reaching 78 in the case of the 25-to-27-year age group.

This analysis indicates that between 1930 and 1934 there was a substantial net loss of employment by the engineers active before 1930, and a considerable absorption in employment of newcomers to the profession. Some of this shift may have been due to direct displacement; some of it to the securing of newly created positions by the younger men. There is no evidence bearing on the proportions affected by these two tendencies.

TABLE VII. INCREASES OR DECREASES IN EMPLOYMENT OF OLDER ENGINEERS AND YOUNGER ENGINEERS, BY CLASS OF EMPLOYMENT, 1929 TO 1934
(Adjusted Figures)

EMPLOYMENT CLASS	TOTAL NUMBER REPORTING			INCREASE OR DECREASE			
				1929 to 1932		1932 to 1934	
	1929	1932	1934	Older[1] Engineers	New[2] Entrants	Older[1] Engineers	New[3] Entrants
All classes	27,988	28,694	32,735	−2,862	+3,568	+668	+3,373
Private firm	19,424	16,416	17,534	−4,530	+1,522	−472	+1,590
State, county, and municipal government and other public authority	4,948	5,677	5,804	+174	+555	−101	+228
Federal government	1,647	2,312	3,872	+416	+249	+1,086	+474
Non-engineering	1,969	4,289	5,525	+1,078	+1,242	+155	+1,081

[1] Includes all engineers who were professionally active prior to 1930.
[2] Includes all engineers who entered the profession in the years 1930 to 1932 inclusive.
[3] Includes all engineers who entered the profession in the years 1933 and 1934, and also came in during this period from classes of 1930–1932.

Metropolitan Section to Give Prizes to Student Chapter Members

The Metropolitan Section, through action of its Board of Directors, has announced an annual award of eight prizes for the eight Student Chapters in the Metropolitan Conference of Student Chapters, beginning with the spring of 1937. The outstanding member of the senior class in each of the institutions will receive an award consisting of the payment of his initiation fee as a Junior of the Society, a Junior badge, one year's dues to the Metropolitan Section, and a certificate of award.

To be eligible for this award a student must be (1) a member in good standing of the Student Chapter of the Society, and (2) a member of the senior class graduating during that calendar year from the standard course of the college leading to a degree of B.S. or its equivalent.

Students meeting these requirements will be rated by their faculty adviser and contact member on the following basis:

Scholarship	50 per cent
Student Chapter Activities	20 per cent
Other activities (extra-curricular)	10 per cent
General characteristics, including personality, personal appearance, loyalty, initiative, resourcefulness, etc.	20 per cent

In each Chapter the faculty adviser and contact member will nominate two candidates. The Section's Committee on Student Chapters, composed of the faculty advisers and contact members of the eight Chapters, will then examine the records of the candidates. The recipient of each award will be determined by a vote of the committee.

The first formal award will be made at the annual meeting of the Metropolitan Section on May 19, 1937. The Metropolitan Section has consistently and staunchly supported the Conference of Metropolitan Student Chapters formed in 1933. The new awards are a continuation of that generous support and are evidence of the steadily increasing interest in young engineers that is being shown by many of the Local Sections of the Society.

Fourth Annual Report of Engineers' Council Published

The Fourth Annual Report of the Engineers' Council for Professional Development (E.C.P.D.), of which the Society is a member body, is now off the press. An attractively arranged, grey-covered pamphlet of 32 pages, it contains reports of the four main committees of the Council—those on student selection and guidance, on engineering schools, on professional training, and on professional recognition.

Of considerable interest are two glowing tributes to the late Robert I. Rees, who was vice-chairman of E.C.P.D. and chairman of its Committee on Professional Training and Committee on Ways and Means, prepared by Robert M. Lester, secretary of the Carnegie Corporation of New York, and Charles F. Scott, chairman of E.C.P.D.

A list of accredited undergraduate curricula for the New England and Middle Atlantic Region appears as an appendix to the report of the Committee on Engineering Schools. The list, given both by institutions and by curricula, comprises thirty-five institutions. The Committee on Engineering Schools is now engaged in reviewing curricula in other states. It is expected that the complete and revised list will be ready in the fall of 1937.

Results of some recent work with a group of junior engineers in Providence, R.I., are given as an appendix to the report of the Committee on Professional Training. Providence was selected as one of the places where a program for the development of young engineers was to be launched. The Providence Engineering Society cooperated wholeheartedly in the movement. Worth-while results have been obtained.

Copies of the Fourth Annual Report can be secured from the Engineers' Council for Professional Development, 29 West 39th Street, New York, N.Y., at a cost of 25 cents each.

California Engineers Take Active Interest in Legislative Matters

On March 19, 1937, there was formed at Sacramento, Calif., a "State Engineering Legislative Committee." It consists of the four Local Sections of the Society in the state—Sacramento, San Francisco, San Diego, and Los Angeles—together with the Structural Engineers' Association of Northern and Southern California and the Los Angeles Engineering Council.

This committee has given its attention to more than fifty bills now before the California legislature that affect, directly or indirectly, the engineering profession. Some twenty bills were approved, in some cases with suggestions for amendment; an almost equal number were opposed; and the remainder were not acted upon but "are to be watched."

The proposed legislation covers a wide variety of subjects. On the "approved" list, among others, were a professional engineers' registration bill amendment, a bill authorizing injunction proceedings against persons violating the licensing act, a bill requiring the trustees of each school district to make periodic examinations of school buildings and equipment, and one permitting the consolidation of the offices of road commissioner and county surveyor. Among the bills opposed was one that would blanket into registration all state employees who have been classified as engineers.

Engineering Foundation Reports Activities for the First Quarter

Progress on a variety of projects during the first quarter of 1937 is reported by the Engineering Foundation. Of special interest to civil engineers is the research work being carried on by the newly formed Soil Mechanics and Foundations Division of the American Society of Civil Engineers through its Committee on Foundations and its Committee on Seepage and Erosion. A report of the Society's Committee on Hydraulic Research, another activity to which the Foundation has appropriated funds, appeared in the March 1937 issue of Civil Engineering.

The second volume of *The Alloys of Iron and Carbon*, prepared by the Iron Alloys Committee of the Foundation, was published in February. Also, a recent report has been prepared on the barodynamic research being conducted at Columbia University. Publications dealing with the work of the Foundation's Welding Research Committee are being issued monthly, and the research project on the stability of impregnated paper insulation is being actively prosecuted. Work on electric shock research has not yet been started. In addition, a number of projects of the American Society of Mechanical Engineers, Engineers' Council for Professional Development, Personnel Research Federation, and the University of California are in progress.

A resolution of the Board of Engineering Foundation memorializing Alfred D. Flinn, M. Am. Soc. C.E., late director of the Foundation, is noted in detail elsewhere in this issue.

Appointments of Society Representatives

L. F. Bellinger, M. Am. Soc. C.E., was appointed to represent the Society at the inauguration of James Rion McKissick as president of the University of South Carolina on April 6.

Harry L. Bowman and William H. Chorlton, Members Am. Soc. C.E., and Charles A. Howland, Assoc. M. Am. Soc. C.E., were appointed to represent the Society at the annual meeting of the American Academy of Political and Social Science, to be held in Philadelphia, Pa., on April 16 and 17.

W. W. Horner, M. Am. Soc. C.E., represented the Society at a meeting of the Mississippi Valley Association on flood control and related problems, which was held in St. Louis, Mo., on March 12.

Howard S. Morse, M. Am. Soc. C.E., represented the Society at the inauguration of Clyde Everett Wildman as president of De Pauw University at Greencastle, Pa., on March 10.

Preview of Proceedings

By HAROLD T. LARSEN, *Editor*

Part of the May issue of "Proceedings" was "previewed" in the April number of "Civil Engineering." Due to the last-minute need for changes, one or more of these papers may be still further deferred. It is certain, however, that "Proceedings" for May will contain a variety of technical subjects, of interest to the designers of dams, to foundation engineers, and to surveyors. One to be included is the paper by Richard R. Randolph, Jr., entitled "Hydraulic Tests on the Spillway of Madden Dam." It was described in the April "Preview of Proceedings."

EARTHQUAKE RESISTANCE OF ELEVATED WATER TANKS

Wherever earthquakes are likely to occur, the question of safety to the water supply is of paramount importance. The danger to a municipal supply or to an important industrial supply is apparent at once; but the threat to water supply caused by the collapse of numerous individual elevated water tanks is none the less important. Encouraged by the Associated Factory Mutual Fire Insurance Companies, Arthur C. Ruge, Assoc. M. Am. Soc. C.E., research associate in seismology at Massachusetts Institute of Technology, several years ago began an intensive study of this class of structures. The complete report of this research is scheduled to appear in PROCEEDINGS for May under the title, "Earthquake Resistance of Elevated Water Tanks." The standard of tanks chosen for study was one with a capacity of 60,000 gal placed on a tower 100 ft high. Models of such a tank were constructed to scales of 1:46.5 and 1:25 and tested on a specially designed shaking table. The models were provided with spring elements in the diagonal sway rods to simulate a new type of construction to be investigated.

The problem of building elevated tank structures that will actually withstand earth shock is considered in detail, and a new type of construction involving the installation of special damped springs, is suggested as a practical solution.

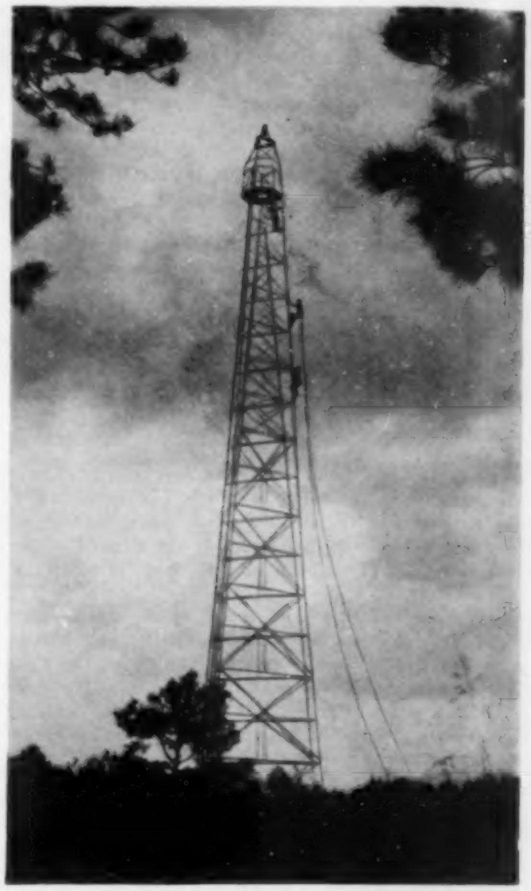
The paper is well organized and contains a number of detailed conclusions and suggestions for design. For example, on the basis of his studies, Professor Ruge declares that the standard type of elevated tank towers now in common use is poorly adapted for withstanding earthquakes of destructive intensity. He recommends increasing the safe deflection of the towers to at least 15 in., at the same time providing a snubbing action to destroy resonance effects. The columns and struts should be so designed that the rod bracing would fail first if the structure were tested to destruction by static horizontal loading.

CLOSING DISCUSSIONS

At least eight papers, which have been actively discussed for several months, will be formally closed by their respective authors in the May issue of PROCEEDINGS. Those that are definitely in prospect as this preview goes to press are "Administrative Control of Underground Water: Physical and Legal Aspects" by Harold Conkling, M. Am. Soc. C.E.: "Simplified Method of Determining True Bearings of a Line" by Philip L. Inch, Assoc. M. Am. Soc. C.E.; "The Modern Express Highway" by Charles M. Noble, Assoc. M. Am. Soc. C.E.; "Structural Application of Steel and Light Weight Alloys: Tests of Engineering Structures and Their Models" by R. L. Templin, M. Am. Soc. C.E.; "Simultaneous Equations Solved by Iteration" by W. L. Schwalbe; "Dynamic Distortions in Structures Subjected to Earth Shock" by Harry A. Williams; "Stable Channels in Erodible Materials" by E. W. Lane, M. Am. Soc. C.E.; and "Analysis of Vierendeel Trusses" by Dana Young, Assoc. M. Am. Soc. C.E.

READJUSTMENT OF TRIANGULATION DATUM

When the federal government readjusted the basic triangulation system of the United States and established the so-called "1927 North American Datum," all organizations, civil and governmental, faced a tremendous problem, because the cost of recomputing the adjusted location of every established point would be excessive. For this reason the U. S. Geological Survey began investigating methods of adjustment by means of corrections to the older values. A paper by Julius L. Speert, Jun. Am. Soc. C.E., entitled "Readjustment of Triangulation Datum," contains a description of several of the methods (notably three) that have been developed. These are as follows: (1) An analytical determination of the new position by applying formulas of translation, rotation, and linear change; (2) a graphical method for determining corrections by plotting lines of equal position changes; and (3) a mechanical method requiring an easily constructed transparent rotating guide. Each of the methods is based upon approximations, but since the actual quantities considered are very small, they can be only approximate and still give results within the required accuracy of the original survey.



PORTABLE STEEL TRIANGULATION TOWER AS DEVELOPED BY THE U. S. COAST AND GEODETIC SURVEY

News of Local Sections

BUFFALO SECTION

There were 65 members and guests present at the March meeting of the Buffalo Section, which took place at the Buffalo Athletic Club on the 9th. On this occasion the speaker was James O'Connor, district engineer for the U. S. Engineer Office, who discussed various phases of flood control. The annual meeting of the Section, held at the Buffalo Athletic Club on March 30, was preceded by a dinner in honor of George T. Seabury, Secretary of the Society, who was the principal speaker. Among the others at the speakers' table were Henry E. Riggs, former Vice-President of the Society; C. Arthur Poole, Director from District 3; and Edward P. Lupfer, Vice-President from Zone I. The meeting was held under the chairmanship of William P. Feeley, president of the Section. The 1937-1938 officers of the Section will be as follows: George S. Minniss, president; Henry E. Riexinger, vice-president; Melvin C. Kelly, secretary; and Nelson Stone, treasurer.

CENTRAL ILLINOIS SECTION

On March 12 a regular meeting of the Central Illinois Section took place at the St. Nicholas Hotel in Springfield. The attendance of 70 included members of the Springfield Engineers' Club and the Association of Highway Engineers. Following dinner and the transaction of routine business, Jacob A. Harman explained the provisions of the proposed bill for the registration of professional engineers in the state of Illinois. After considerable discussion a resolution endorsing the provisions of this bill was unanimously adopted.

CENTRAL OHIO SECTION

Members of the Central Ohio Section met at the Chittenden Hotel in Columbus on March 18 for their monthly luncheon. The feature of this gathering was a talk by Lynn Black, superintendent of the Ohio State Highway Patrol, who described the accomplishments of the Patrol since 1933 when it was authorized. He also emphasized the engineer's responsibility to eliminate all unnecessary hazards within his control. There were 26 present.

CLEVELAND SECTION

The regular monthly meeting of the Cleveland Section took place at the Cleveland Chamber of Commerce on April 6. The 40 members and guests present enjoyed a talk by G. E. Barnes, head of the department of civil engineering at the Case School of Applied Science, on "Education for Civil Engineers." Professor Barnes outlined the aims and new developments in civil engineering courses and emphasized the necessity of graduate engineers taking a genuine interest in student training.

COLORADO SECTION

There were 55 present at the meeting of the Colorado Section, held at the Denver Athletic Club on March 8, and 40 at the dinner preceding it. Director T. A. Leisen and Vice-President Roy C. Gowdy discussed various matters taken up at the last meeting of the Board of Direction. They were followed by Arthur O. Ridgway, chief engineer of the Denver and Rio Grande Western Railroad, who spoke on "Research and Experimentation in Railroad Engineering."

The twenty-first regular meeting of the Junior Association of the Colorado Section took place on March 22. On this occasion the speaker was R. E. Clark, senior forester for the U. S. Forest Service, whose topic was "The Relation of National Forests to the Community."

DAYTON SECTION

The regular March meeting of the Dayton Section took the form of a luncheon at the Engineers' Club. An illustrated talk on the instruments used in blind flying was given by Carl J. Crane, of the U. S. Army Air Corps, who described the difficulties suffered by early pilots in navigating without accurate instruments. Captain Crane's talk was preceded by a demonstration in which members of the Section assumed the rôle of pilot and, by means of an instrument, actually experienced the difficulties under which early flying was accomplished. The attendance at the meeting numbered 20.

DETROIT SECTION

A joint meeting of the Detroit Section of the Society and the newly organized Engineering Society of Detroit was held at the Masonic Temple on February 17, with 1,600 present. This capacity audience was attracted by an illustrated talk on the San Francisco–Oakland Bay Bridge, given by Charles F. Goodrich, chief engineer of the American Bridge Company. An enthusiastic question-and-answer period followed the lecture. Preceding the meeting proper, Mr. Goodrich was guest of honor at a dinner, which was attended by 135.

GEORGIA SECTION

Numerous business matters were considered at a meeting of the Georgia Section, which was held at the Atlanta Athletic Club on March 8. The technical program consisted of a talk by G. Leazer, who gave an interesting résumé of the development of aviation and landing fields. In his talk Mr. Leazer brought out the fact that the engineer has played an important part in the advancement of aviation through his knowledge of the proper method of constructing landing fields. Several members of the Georgia School of Technology Student Chapter were among the 24 present.

KANSAS CITY SECTION

There were 91 members and guests present at the first spring meeting of the Kansas City Section, which was held at the Hotel President on March 9. An interesting and timely talk on recent studies of the Missouri River was given by R. C. Moore, district engineer for the Corps of Engineers, U. S. Army. Colonel Moore's talk included comment on the causes of floods and the prevention of flood damage in the future. At the conclusion of the meeting, the president announced that 66 members had affiliated with the Local Section.

KANSAS STATE SECTION

On March 22 the Kansas State Section of the Society collaborated with the Kansas Engineering Society and the Topeka Engineers' Club in giving a dinner meeting at the Kansas Hotel in Topeka. Following dinner, Willard T. Chevalier, vice-president in charge of *Engineering News-Record*, discussed the engineer of the present and the future as contrasted with the engineer of yesterday. Colonel Chevalier pointed out that only in so far as engineers are able to increase the productivity of men and matter can they hope to be instrumental in contributing towards a higher standard of living in general. There were 124 present at this meeting, which was one of the largest of its kind ever held in Kansas.

METROPOLITAN SECTION

The relation of geology to engineering was the topic of discussion at a meeting of the Metropolitan Section, held in the Engineering Societies Building in New York City on March 17. The main paper was presented by William O. Hotchkiss, president of Rensselaer Polytechnic Institute, who stated that one of the principal problems in trying to predict the bearing properties of various ground materials is to utilize the information obtained from samples tested under conditions very different from those existing in the original state. In the discussion that followed Alfred V. Sims, proprietor of the Sims Pump Valve Company, of New York City, described an interesting experiment that he had performed in his laboratory to show the high bearing value of sand when it is supported laterally. Mr. Sims applied pressure on the surface of sand enclosed in a 6-in. pipe, 1 ft. long, while he held a finger in the sand through a hole near the bottom of the pipe. When the pressure reached the alarming amount of 100,000 lb, he still felt no additional pressure at the lower end of the sand column, showing that the arch action of the sand was transmitting this pressure down through the sides of the pipe. There were about 400 present.

NEW MEXICO SECTION

A regular meeting of the New Mexico Section was held in the State Welfare Building in Santa Fe on January 13. During the business session several committee reports were heard, and R. H. Rupkey was appointed to serve as chairman of the program committee. The president then introduced Fred C. Scobey, senior irrigation engineer in the Bureau of Agricultural Engineering of the U. S. Department of Agriculture. Mr. Scobey gave an instructive illustrated talk on the flow of water in open conduits.

NORTHEASTERN SECTION

A meeting of the Northeastern Section took place at Pierce Hall on the campus of Harvard University on March 31, with approximately 300 in attendance. Many of the guests were members of Student Chapters in the vicinity. The speaker of the evening was H. De Silva, of the Bureau for Street Traffic Research at the university, who discussed the methods and apparatus used in testing automobile drivers for glare-blindness, visual keenness, visual depth perception, "tunnel vision," speed, and timing estimation and vigilance. Prior to the meeting, 21 members of the Section attended a dinner at the Faculty Club at Harvard. On February 19 a joint meeting of the Section, the Boston Society of Civil Engineers, and the Student Chapters at Harvard and at Massachusetts Institute of Technology was held in the new lecture hall at Harvard. The feature of the occasion was an illustrated lecture on the San Francisco–Oakland Bay Bridge, given by Charles F. Goodrich, chief engineer of the American Bridge Company.

PANAMA SECTION

There were 25 present at a meeting of the Panama Section held at the Union Club in Panama City on February 24. A talk on current construction activities in the United States was given by E. S. Randolph, designing engineer of the Panama Canal. Mr. Randolph, who has just completed an extended tour of the United States, described a number of projects in the Pittsburgh region and the Ohio Valley.

PHILADELPHIA SECTION

About 40 members of the Philadelphia Section and their friends enjoyed a dinner at the Engineers' Club, prior to the meeting of the Section which took place on March 17. The meeting was held under the chairmanship of C. H. Stevens, who introduced the speaker of the evening, E. Warren Bowden, assistant to the chief engineer of the Triborough Bridge Authority, New York City. Mr. Bowden's address was built around a large number of lantern slides which covered the project from the original planning of the scheme to the completed structure. Some of the details of construction as well as pertinent facts and figures as to cost, quantities, and details of design were also brought out. Following the lecture, a social hour was enjoyed and light refreshments were served.

PROVIDENCE SECTION

The Providence Section held a meeting on March 29 in the Providence Engineering Society Building. The general subject of discussion was aerial surveys, and there were two speakers—Arthur W. Lambert, Jr., and Ivan C. Whipple, both of the Providence office of the U. S. Engineer Office. Mr. Lambert discussed the stereoscopic principles used in making aerial surveys and described the apparatus used, while Mr. Whipple told how maps are made from aerial photographs. Both talks were illustrated by exhibits and stereopticon slides. There were 70 present.

SACRAMENTO SECTION

Members of the Sacramento Section of the Society enjoyed weekly luncheon meetings during March. At the session held on the 2d, Hilton F. Lusk, instructor of aeronautics at Sacramento Junior College, gave a talk on "The Douhet Doctrine of Modern Aerial Warfare and Its Influence on World History." There were 42 present. The meeting held on March 9 attracted an attendance of 45. On this occasion Frank B. Durkee, attorney for the California Department of Public Works, spoke on "The Background of the Constitution." A résumé of engineering history in the West was presented, at the meeting held on March 16, by J. I. Ballard, editor of *Western Construction News*. There were 39 present. The meeting on March 23 was dedicated to the Juniors, Merle E. Fischer being chairman of the entertainment committee. The speaker was Alfred D. Coons, resident engineer of the College of Agriculture at the University of California. "The Art, Science, and Mathematics of Finger Prints" was the subject of an illustrated lecture given, on the 30th, by Clarence S. Morrill and Roger S. Greene, of the California Department of Penology. There were 63 present. Members of the Sacramento Section also participated in a joint dinner meeting held in Sacramento on March 19, with the Los Angeles and San Francisco Sections and the Structural Engineers Associations of Northern and Southern California.

SAN DIEGO SECTION

A meeting of the San Diego Section was held on February 25. There were 18 present on this occasion to hear Prof. Baylor Brooks, of San Diego State College, discuss the geological history of San Diego County. At the meeting held on March 25 the members enjoyed an unusually interesting technical meeting. First, a new method of placing a concrete jacket around steel pipe lines to lessen corrosion was shown by a motion picture. The picture was presented and the method discussed by its originator, Sterling C. Lines, consulting engineer of Los Angeles. Mr. Lines has devised a machine that rides along the pipe, forming the concrete coating as it goes. Then Fred D. Pyle, city hydraulic engineer of San Diego, presented a report on the city's water supply made by a consulting board employed by the city for that purpose. This report outlines a workable plan for developing the city's supply for as far ahead as 1980. There were 17 present.

TENNESSEE VALLEY SECTION

The regular meeting of the Knoxville Sub-Section of the Tennessee Valley Section was held at the University of Tennessee on March 4, with an attendance of about 60. The feature of the occasion was the showing of a motion picture on the making of alloy steel, which was presented by John Kilmar, metallurgist for the Bethlehem Steel Corporation. The public relations committee was authorized to advise the Knoxville Chamber of Commerce and the city administration on various local engineering problems, particularly smoke abatement. Another meeting of the Knoxville Sub-Section was held on April 1. On this occasion the speakers were Robert Daniels, sales engineer for the Lincoln Electric Company, and Corbin Chapman, who is in the research department of the Hedges-Walsh-Weidner Company division of the Combustion Engineering Company. The former gave a talk on the development of arc welding during depression years, while Mr. Chapman discussed electric arc-welded pressure vessels and alloy fabrication.

The Muscle Shoals Sub-Section has also held monthly meetings. The list of speakers appearing at these sessions included Ross White, J. F. Roberts, and Oren Reed, all connected with the Tennessee Valley Authority.

TOLEDO SECTION

On March 24 the 1937 annual meeting of the Toledo Section took place at the Park Lane Hotel. During the business session the following officers were elected for the ensuing year: C. B. Patterson, president; P. D. Miller, first vice-president; S. C. McKee, second vice-president; and R. W. Abbott, secretary-treasurer. The feature of the technical program was a talk by Arne A. Jakkula, assistant professor of civil engineering at the University of Michigan. His talk, which was on the history of suspension bridges, was illustrated with lantern slides.

Student Chapter Notes

GEORGIA SCHOOL OF TECHNOLOGY

Members of the Georgia School of Technology Student Chapter recently enjoyed a dinner meeting. A talk on "Job Getting and Job Keeping" by L. F. Bellinger, Vice-President of the Society, proved of interest on this occasion. Another instructive feature was a motion picture entitled "Tests of Guard Rails for Highways," which was shown by Searcy B. Slack, consulting engineer of Decatur, Ga.

TUFTS COLLEGE

The Tufts College Student Chapter held a meeting on November 13, 1936, with 11 in attendance. The feature of the occasion was a talk on neutrality, which was given by the head of the history department at the college. There were 17 present at the meeting held on December 18, 1936, to hear J. S. Crandall give an illustrated talk on harbor and port planning. On March 31 the members of the Chapter collaborated with the Northeastern Section, the Boston Society of Civil Engineers, and local Student Chapter groups in sponsoring an illustrated lecture by Charles F. Goodrich. (An account of this meeting appears in the "News of Local Sections" department of this issue.) On February 15 members of the Chapter made a trip to the Master Builders' Association, where they were guests of Stuart Huckins. After lunch a talk on timber connectors was given.

UNIVERSITY OF NEBRASKA

The activities and duties of the Corps of Engineers, U. S. Army, were discussed by Maj. W. A. Wood at a recent meeting of the University of Nebraska Student Chapter. Another feature of the occasion was the showing of the Society's illustrated lecture on Wilson Dam, which was presented by Alfred Chase.

UNIVERSITY OF NEW MEXICO

On March 9 the University of New Mexico Student Chapter collaborated with the local student branch of the American Society of Mechanical Engineers in holding a joint meeting. The Society's illustrated lecture on the Hetch Hetchy water supply project, shown by Dee Mowrer, was greatly enjoyed. Then a paper on air conditioning was presented by Gerald Moynihan, a mechanical engineering student at the university.

ITEMS OF INTEREST

Engineering Events in Brief

CIVIL ENGINEERING for June

AMONG the articles scheduled for the June issue is another by Warren J. Mead, Affiliate Am. Soc. C.E., professor of geology at Massachusetts Institute of Technology, on the engineering geology of dam sites. This second article deals with dam sites in shale and earth. The constitution and physical properties of shale are discussed in detail, and a distinction is made between compaction shales and cemented shales. Problems of bearing strength and elastic properties, resistance to sliding, prevention of leakage under or around the dam, and preparation of foundations in shale are next considered. Foundations of earth dams are treated comparatively briefly, with special attention to those founded on alluvial deposits.

Reaction-time and traffic behavior of motorists are the subject of an article by Bruce D. Greenshields, Assoc. M. Am. Soc. C.E., professor of engineering science at Denison University, Granville, Ohio. These two factors have an important bearing on highway design and safety work. However, a reduction in reaction-time would probably be more effective in speeding up traffic and increasing road capacities than in lessening accidents. Investigations of the relations between reaction-time on the one hand and vehicle spacing and driving ability on the other have been made in various parts of the country. The results of several of these investigations are summarized in the article, which also includes a description of some recent laboratory tests to determine the average duration of time of reaction.

In another article scheduled for the June number of CIVIL ENGINEERING, by Philip Kissam, Assoc. M. Am. Soc. C.E., associate professor of civil engineering at Princeton University, the advantages of the plane-coordinate system are demonstrated in connection with the recent establishment of a straight boundary line for three New Jersey counties where the original markers were not properly lined up. Use of this system made it possible to base the entire survey control on the U. S. Coast and Geodetic Survey's fundamental triangulation net without resort to geodetic computations, and also made it relatively easy to locate the most probable position of the boundary as a straight line by the method of least squares. The general formula applied in this phase of the work will unquestionably prove helpful to those who may be faced with similar problems.

If space permits, there will be included an article on flood-control problems at Chattanooga, by E. L. Chandler, M. Am. Soc. C.E., chief estimator, TVA, Knoxville, Tenn. The dams to be built upsteam by TVA will provide a material part of the control necessary, and it is hoped that their construction will make it possible for the city to achieve complete security by means of a $15,000,000 program of local flood-protection works. The plan for these works, proposed by the Chattanooga Flood Protection District in cooperation with the Tennessee Valley Authority, contemplates in general building levees and walls and relocating creek channels, together with construction of the necessary sewer lines, flood gates, and pumping stations.

Picturesque Ancient Water Tower

ON THE Page of Special Interest, in the front part of this issue, is a reproduction from a watercolor painting of an ancient water tower. This tower at Los Remedios, near Mexico City, exemplifies water-supply engineering of another era. The structure is built of stone, following scientific principles of design, it is said. It was evidently intended for use as a fortress in case of attack. Report states that the structure is "centuries old."

Engineering and architectural structures of other days abound in Mexico. This one, with its aqueduct to Mexico City, exemplifies the art of a neighbor country. Similar pleasing features of Mexico, in the northeastern part of the republic, add to the attractions of the trip to Monterrey, arranged for those attending the Spring Meeting at San Antonio.

The original painting of this old water tower, done in a modern style by Walter Murch of New York City, is here reproduced as one in the series of "Art in Engineering" being featured currently on the Page of Special Interest. It serves to demonstrate that the structures built by engineers centuries ago were designed with an eye to art, and even with what today appears as a modernistic touch.

Wise and Otherwise

AN OLD PROBLEM in somewhat novel form has been submitted to Professor Abercrombie by Frank J. Schmidt, Jun. Am. Soc. C.E., as follows:

A scout on horseback started from the rear of a column of soldiers 4 miles long marching at the rate of 4 miles per hour, and traveled at a uniform rate to the head of the column. Having delivered a message without pausing for a moment, he reversed his direction and proceeded to the rear at the same rate. If the trip was completed in exactly one hour, what was the scout's speed?

April's problem was concerned with a "pursuit" curve, as shown in Fig. 1. A child leaves the side of its mother M, who is standing at a right-angled intersection of two straight roads, and wanders at a uniform rate up the crossroad. At the same moment the father, F, gives chase directly across fields at a uniform rate of 600 ft per minute, moving always directly towards the fugitive, as indicated by the

FIG. 1. DIAGRAM OF PURSUIT CURVE

line F_1C_1, for example. He captures the child at C and maintains his original speed back along the crossroad to the mother, the total time consumed being 4 minutes. A test run at the same speed from F to M is found to consume 2 minutes. The formula for the length of the curve between tangent points F and C is given as $c = \frac{a}{1 - r^2}$, in which a is the distance between the origin of coordinates M and the initial tangent point F, and r is the ratio of the child's speed to the father's speed. With this information, it was required to find the child's speed.

At first glance the problem appears incapable of solution, as its author, Prof. E. L. Ingram, points out, since all three of the values involved are unknown. But, he continues, only relative values have any bearing on the question, as the shape of the curve is unchanged as long as the ratio r remains the same. Obviously, since the product of velocity and time is distance, if d represents the distance MC traversed by the child, then $d = \frac{ra}{1 - r^2}$.

Let the total distance traversed by the father from the start to the intersection M be represented by s.

Then $s = c + d = \frac{a + ra}{1 - r^2} = \frac{a}{1 - r}$.

From this relationship, $r = 1 - \frac{a}{s}$

The distances a and s being proportional to the times of travel, $r = 1 - \frac{2.67}{4} = \frac{1}{3}$.

The child's speed is thus one-third that of its father, or 200 ft per minute.

Suggestions for other problems for Professor Abercrombie's column, accompanied by solutions, may be addressed to the editor. Solutions should preferably be sent in separate enclosed envelopes.

Jobs for Engineers

Abstracted from an Article First Published in the "Armour Engineer and Alumnus"

By MONROE A. SMITH

MANAGER OF SALES PERSONNEL, UNITED STATES GYPSUM COMPANY, CHICAGO, ILL.

IT IS quite reasonable for the technical student to conclude that unless he applies what he has learned at college to the practice of professional engineering, the time and money spent for his education are a total loss. Since life is short and money difficult to obtain, engineering graduates are apt, by their insistence on immediate employment in engineering work no matter how trivial or illy paid, to create the impression that an oversupply of engineers exists, and to produce in the employer a consideration of the possibility of lowering the salaries of those already working at the minor tasks of engineering. There is naturally considerable "professional" feeling in the recent graduate, who feels all ready for an engineer's work after his four years' grind. The acceptance of a non-engineering job makes him feel like a traitor to his ideals.

The demand for engineers constantly varies—and more frequently against the graduate than in his favor. In the freshman year at college men elect the particular branch of engineering they desire to pursue on the basis of the then supposed demand for civils, electricals, mechanicals, etc. Of course, they have nothing but conjecture, gossip, and inexperience to guide them in their choice; but even if facts are available and decisions carefully and correctly drawn, there never is any assurance that the conditions on which the students' conclusions are based will not change several times during the four-year period of undergraduate work.

How, then, can we say that there is work—useful work and plenty of it—for engineering graduates? Isn't it that our concept of what constitutes engineering is a narrow one; that in confining our appreciation of what we have learned to its usefulness in solving textbook problems we fail to see its wider, more useful application to the field of business?

All men who are labeled engineers because of a collegiate degree are not entitled to the distinction. The label "engineer" should mean more than a man who can design "engineering works," or assemble a heterogeneous collection of devices into a planned whole to produce a factory, railroad, water works, sewer system, or CCC camp. Surely the power to "do it better for less" involves two fundamental kinds of engineering ability, the creative or inventive, and the managerial. The first will take an existing problem and by creating a more efficient motor, engine, or detail, improve the product, cut the cost, or both. The second will take the same assembly, and through investigation and analysis of its functions, without in any way altering the device, produce a more efficient whole through proper management and coordination of the parts. The true engineer may be expected to have either an inventive ability, a managerial ability, or a combination of both.

An engineering education does more than produce engineers in the narrow definition usually associated with it by the profession. Engineering, in fact, is an excellent training for a broader application of human intelligence than it is generally conceived to be at the universities.

The manufacturer who is expected to foot part of the expense of education has constantly cried for practicalness. The educators, perhaps reluctantly, have answered his demands by creating a multiplicity of specialized schools involving commerce, management, journalism, finance, physical education, sociology, and a constantly increasing number of engineering branches, where fifty years ago there were only law, medicine, science, engineering, theology, and liberal arts.

It is not always possible to give immediately practical education in any subject in school, but it is and has been possible to provide and compel an experience in the mental gymnastics which are as necessary to success for the average man as the training table and physical gymnastics are to the athlete.

Engineering does this as no other course of instruction. Fundamentally, engineering is a training in the scientific marshaling of facts; in methods of analysis which can tear complex ideas into their simpler elements; in the synthetic processes which weld them together into a new and more useful form.

Business does not want guesswork in its reports, accounts, and analyses, any more than does the engineer in his data, calculations, and drawings. Business is built on facts, and facts are certainly the province of the engineer. Why then should the engineer feel that he has prostituted his ideals if he applies his ability to manage facts to the gain of his employers and himself in general business? Minds drilled in mathematics and the logic of engineering are sound minds that prove their conclusions—safe minds trained to manage—and there are not nearly enough of them.

It is not always easy for engineers to secure non-engineering jobs. All business men are not convinced of the advantage of engineers in jobs which do not involve the manipulation of slide rules, triangles, and drawing pens. Too often the engineering students whom the business man is persuaded to interview do not exhibit the benefits of education normally gained in grammar and high schools to the degree shown by the graduate of liberal arts or commerce. The engineer's knowledge of elementary English, history, and current events is weak. He is restricted by his desire to be an engineer and confines his reading largely to technical subjects.

Then he is so careful to avoid being called a "sissy" that he affects a tough, "hard-boiled" make-up. The flannel shirt of the laboratory or camp may be only partially concealed by an outmoded suit redolent of mothballs. His general appearance as compared to the average man seeking employment is below par. His social graces during the introduction and departure are more those of a yokel than a collegiate. The collegiate styles affected by the liberal arts student are bad enough in an office, but those of the engineer are definitely worse.

To the student I would say "Try to avoid it"; and to the business man, "Ignore it." The engineer is smart enough and alert enough to see how he differs from the other boys in your office in a few months, and with the aid of a few pay checks, his exterior should show marked improvement. The contact with his fellows will probably awaken him to the fact that slide rules, triangles, and drawing pens are not the only tools of trade.

Engineering is a broad and useful course of study. The graduate seeking employment should not permit himself to be limited by the fact that he studied engineering, or even that he studied some specific branch of engineering. He should accept the broader view that he has been trained to think logically, to handle facts, and eventually to establish that he can be trusted with the management of men and ideas. He will have to do all of this if he is to succeed as a professional engineer or business man.

In the last five or six years most of the engineering graduates have been thankful to do anything from running errands for the telegraph company to making exact determinations of the height of the oil in the crank case of a Ford, but even during times of great stress, it is possible for the young engineer who determines through self-analysis what job he is fitted for, to find an opening to such a job.

A.R.E.A. Elects Officers

AT THE thirty-eighth annual meeting of the American Railway Engineering Association, held in Chicago, Ill., March 15–18, 1937, James C. Irwin, valuation engineer for the Boston and Albany Railroad, was elected president of the association. The other officers elected during this meeting were E. M. Hastings, second vice-president; F. E. Morrow, first vice-president; and F. L. Nicholson, C. S. Kirkpatrick, and J. B. Hunley, directors. With the exception of Mr. Hunley, all these engineers are members of the Society.

Summer Conferences of Interest to Engineers

ANNOUNCEMENTS of four conferences to be held during the summer in various parts of the country have recently been received at Society Headquarters.

The Society for the Promotion of Engineering Education and the Stevens Institute of Technology are jointly sponsoring the seventh annual economics conference

for engineers at the Stevens Engineering Camp, Johnsonburg, N.J., June 18 to 26. Among the lecture subjects are: "What Engineers Should Know About Labor Problems," "Fundamental Changes in Our Economy," and "The Effect of Government Policies on Engineering Industries." Condensed courses are also to be given on industrial economics, industrial psychology, and industrial management. Further information can be obtained from the President's Office, Stevens Institute of Technology, Hoboken, N.J.

At Camp Marston, Minn., the S.P.E.E. and the civil engineering department of Iowa State College will jointly conduct a surveying conference, July 25 to August 7, inclusive. The object is to improve the teaching of surveying in American colleges. The various topics will be introduced by speakers considered as authorities on the particular questions involved, and will then be developed further in round-table discussion. Details can be secured from Prof. J. S. Dodds, M. Am. Soc. C.E., Iowa State College, Ames, Iowa.

Through the cooperation of the Board of City Planning Commissioners of Los Angeles, the Ninth Annual Institute of Government at the University of Southern California is to include a section devoted to "Planning." National and international authorities will lead the discussions, June 14 to 18 inclusive.

At Wellesley, Mass., July 3 to 17, the Summer Institute for Social Progress will aim to bring the engineer's point of view, together with that of business and other professional men and women, to bear on current economic and social problems. The general subject is "The World Challenge to Democracy—How Can America Meet It?" The program includes lectures, discussion groups, and forums. Those interested in taking part should write to G. L. Osgood, 15 West Elm Avenue, Wollaston, Mass.

Engineering Foundation Memorializes Dr. Flinn

At a meeting of the executive committee of the Engineering Foundation, held March 22, 1937, a memorial was offered to Dr. Alfred Douglas Flinn, Member and former Director, Am. Soc. C.E., and director of the Engineering Foundation, who died on March 14, 1937, after a considerable period of illness.

After a biographical account of Dr. Flinn's career (also summarized in the obituary notices in Civil Engineering for April) the memorial continues as follows:

"Director Flinn was a most enthusiastic and sincere worker for Engineering Foundation and put his whole heart and soul into the work. He not only directed the many ventures in research but was also very effective in raising extra funds for the work.

"As a result of his wide influence in the engineering profession Doctor Flinn accomplished a great deal in making the engineer conscious of the broader implications of engineering and research, and in bringing to the attention of the public the work of the engineering profession. Thus he helped to integrate the activities of the engineer with many national interests.

"He was a member of many professional and scientific societies, including the American Society of Civil Engineers and the American Institute of Mining and Metallurgical Engineers, and contributed several technical papers to these societies. He was one of the authors of *The Waterworks Handbook*, was editor of *Research Narratives*, and at one time was managing editor of *The Engineering Record*.

"Doctor Flinn received many honors, including the honorary degree of Doctor of Science from the University of Louvain in 1927, and Doctor of Engineering from Worcester Polytechnic Institute in 1932. He was an honorary member of the Masaryk Academy of Prague and 'Knight, Order of the White Lion,' of Czechoslovakia.

"Resolved: The members of the Board of Engineering Foundation desire to express their appreciation of the services of Director Flinn, both to the Foundation and to science, and order this memorial to be transcribed in their minutes and instruct their secretary to transmit a copy to his family, to Mr. Ambrose Swasey, to United Engineering Trustees, Inc., and to the Founder Societies."

Navy Appointments to Four Members of Society

From a field of 745 candidates, five men have been selected for commission as lieutenants (junior grade) in the Civil Engineer Corps of the Navy. Of these, four are Juniors, Am. Soc. C. E.: Edmonde Bernard Kelly, Adolph Francis Benscheidt, George Sydnor Robinson, and Carl Julius Scheve. The fifth of the group is Joseph White, of Ohio. Final selections were made following a comprehensive written examination taken by 80 candidates. The field had previously been narrowed by preliminary examination of qualifications, and physical tests.

Messrs. Benscheidt and Robinson have already been commissioned and assigned to duty at the navy yards at Mare Island, Calif., and Boston, Mass., respectively.

Ten other candidates successfully passed the examination and have been placed on an eligibility list from which additional appointments may be made. Of this group seven are Juniors, Am. Soc. C.E.: Raymond Lamoreaux, Francis Leo Brown, John Henry Bringhurst, Jr., Cecil Jefferson Espy, Ira Nankervis Curtis, Charles Herbert Neel, and Clayton Oliver Dohrenwend.

That eleven of the fifteen who passed this examination were Juniors of the Society is a matter in which the entire Society may well take pride.

Letter Symbols as Seen by a Publisher

Engineers as well as mathematicians make use of a multiplicity of letter symbols in the course of their work. Frequently on opening a page of an engineering publication, the reader is confronted with a bristling array of integral signs, exponents and subscripts, Greek characters, and what not. A few hardy souls may regard such a page without a qualm, but many are more or less deterred. These may sympathize with the sentiments expressed in an article in a recent issue of *The Kalends*, house organ of the Waverly Press of Baltimore, Md. While this article deals with mathematical journals it is equally applicable to many engineering publications, and is abstracted here because of the discernment underlying its rather amusing manner of expression.

"In *This Simian World* Clarence Day attributes man's ascendancy over other animals to his ability to make and use tools. There is surely more than a modicum of truth in this statement, for without tools this Age of Steel, or Electricity, or Machine, or whatever you want to call it, would have remained an Age of Stone. Or perhaps not even that, for even the Stone Age man had some tools.

"I am not sure just what tools Mr. Day had in mind when he wrote what he did. The chances are that he wasn't thinking of any specific tools at all but rather of the whole range of mechanical implements which man has displayed so much ingenuity in devising. I am quite sure, however, that Mr. Day was not thinking of mathematical symbols as tools; yet these curious little instruments have helped to shape all our lives in a roundabout but none the less significant fashion. Indeed, this might reasonably be called an Age of Mathematics.

"Mathematical symbols affect us here. . . much more directly than they do most people for, in printing four mathematical journals, we must use symbols constantly. In thus using them they become tools, of course, but in a more superficial and different sense from the way a mathematician employs them. He understands their meaning and uses them in expressing his thoughts—we only recognize them as a shape called for in the copy.

"Often I have been curious about some of them for, although I studied some mathematics, my knowledge is much too elementary to follow anything printed in a mathematical journal, so there were many symbols that I could only describe—not explain. Having let my curiosity lead me into finding out, I can now define most of them in somewhat inexact language.

"Many of the symbols used are, of course, so common that every school boy knows them. Ask anybody to name $+$, $-$, $=$, and $\times$ and you'll get the correct answer. The multiplication sign $\times$, incidentally, is rarely used in the mathematical journals, I suppose because it bears too much resemblance to the often used "unknown" x. Mathematicians seem to prefer the centered period, or parentheses (), brackets [], or braces{}. Apparently

multiplication can be indicated in a greater variety of ways than any other operation for, in addition to the four signs above, multiplication is called for by simple juxtaposition. Thus xy, although read simply as xy, means x times y. . . .

"Look through any publication dealing with the subject and you will find a profusion of Greek and German characters, a good deal of bold face, and an occasional Russian letter. I need not say that the necessity of having and setting these different kinds of type complicates the printer's problem. That, to use an expression which mathematicians seem to dislike, is self evident.

"Perhaps you have wondered, as I have, why this profusion of characters is necessary. Whole alphabets of Greek, German, and bold face are never used in any single article; generally only a few of each is required. Why, then, can't standardization reduce this quantity of strange types to a smaller number of more familiar letter forms?

"Possibly this could have been done before the frontiers of the science were so enormously extended. Had there then existed some genie to foresee the course that mathematics would take he might have assigned various characters to various rôles, to the end of simplifying the problem of printing. But now it is too late to hope for either natural or supernatural interference. Through years of use certain characters have acquired significations from which they can never be dissociated. The symbol π immediately comes to mind as a good example of this. Nearly everyone knows that $\pi = 3.14159$ and that it is the ratio of the circumference to the diameter of a circle. The character has become so familiar in this sense that to solve a problem by saying 'Let π = the number of days required for three men to do the work' would be extremely silly.

"Other, less well known examples of this have been pointed out to me: e is the symbol for the base of the system of Napierian logarithms; i is recognized as the symbol for $\sqrt{-1}$; ϵ is generally used to denote a positive quantity; bold face is employed in mathematical papers dealing with vectors or operators. Doubtless there are so many other characters with restricted meanings that mathematicians have been forced into using exotic types. So far, they have absorbed Greek, German, Hebrew, bold face, and a little Russian. Chinese, Armenian, Syriac, Japanese, etc., etc., etc. are still open to them. Heaven knows what will be next! . . ."

Sewage Plant Operators Get Hints from Health Department

INTELLIGENT OPERATION of sewage treatment plants, particularly in the smaller towns, is being promoted by the division of sanitary engineering of the Illinois State Department of Public Health through the medium of a mimeographed quarterly publication called *The Digester*. It is circulated among operators and municipal officials, and the humorous twists given to many of its articles insure it a thorough reading.

Each issue contains considerable technical material, but it is presented in layman's language and from the standpoint of the operator. The following description of the cause of foaming is typical of the general style: "What would happen if we hauled 10 tons of garbage a day to a hog pen which enclosed only one pair of hogs? Wouldn't . . . this enormous amount of foul material . . . create such conditions that even the hogs would soon become sick? If we load a sludge digestion tank with a large amount of raw sludge when the tank does not contain enough bacteria (hogs) to consume it, the same thing occurs—the bacteria become sick and show it by causing the tank to foam."

A series of notes on the activated sludge process was published in 1936, and the current volume includes a similar series on trickling filters. Operating hints contributed by plant managers throughout the state appear in each issue. *The Digester* also includes a question-and-answer department and a "personals" section, and reports the activities of operators' conventions.

Brief Notes from Here and There

Formal greetings of the Society have been extended to the Colombian Society of Engineers, on the occasion of the latter's fiftieth anniversary, which is to be celebrated on May 29, 1937, in Bogotá.

* * * *

AT ITS annual meeting, held on March 17, 1937, the Boston Society of Civil Engineers elected the following officers for the coming year: Arthur D. Weston, president; Gordon M. Fair, vice-president; Everett N. Hutchins, secretary; Charles T. Main, treasurer; and Howard M. Turner and Carroll A. Farwell, directors. The Desmond Fitz Gerald Medal was awarded to Albert Haertlein, associate professor of civil engineering at Harvard University, and a special prize was awarded to John B. Babcock, 3d, professor of railway engineering at Massachusetts Institute of Technology, for his paper on the history of the Boston Society of Civil Engineers. The sanitary section prize went to Almon L. Fales, and the designer's section prize to Herman G. Dresser. All except Messrs. Hutchins and Dresser are Members Am. Soc. C.E.

NEWS OF ENGINEERS

Personal Items About Society Members

E. W. LANE, professor of hydraulic engineering at the University of Iowa, is now associate director of the Institute of Hydraulic Research at the university.

J. R. SHANK, assistant director of the engineering experiment station at Ohio State University, was recently awarded the American Concrete Institute's research medal for the best research paper published in the *Proceedings* of the Institute during the past year.

F. R. WHITE, chief engineer of the Iowa State Highway Commission, has been appointed a representative of the United States on the Permanent International Commission of the International Association of Road Congresses.

E. H. CONNOR is now consulting engineer for the Missouri Valley Bridge and Iron Company, at Leavenworth, Kans. He was formerly vice-president and chief engineer of this organization.

C. E. NICHOLS, for many years associated with the Stone and Webster Engineering Corporation, has accepted an appointment as head civil engineer for the Tennessee Valley Authority, where he will be in charge of specifications, inspection, and testing.

VICTOR A. VOLLMER is now employed by the firm of Fletcher-Thompson, Inc., of Bridgeport, Conn., where he is in charge of structural design. Previously he was associate engineer in the Upper Mississippi Valley Division of the U. S. Corps of Engineers at St. Louis, Mo.

FRANCIS C. CARD, formerly engineering aide for the Tennessee Valley Authority at Knoxville, Tenn., has entered the employ of the Turner Construction Company in New York City.

WALTER STARKWEATHER is now technical assistant engineer to the chief civil engineer of the U. S. Coast Guards, with headquarters in Washington, D.C. For the past several months he has been writing specifications for Coast Guard life-saving stations.

ELLIS R. BROWN, formerly chief of party for the Rural Electrification Survey, of Boston, Mass., has entered the employ of the Austin Company, in the capacity of timekeeper, costkeeper, and assistant engineer on commercial construction work. His headquarters are in New York City.

HARRY ELLSBERG has resigned from the bridge department of the Illinois Division of Highways to enter the employ of the firm of Albert Kahn, Inc., of Detroit, Mich.

SETH G. HESS, assistant state engineer inspector of the PWA for New York, has been named chief engineer for the Interstate Sanitation Commission to study the problem of the pollution of the waters of the metropolitan area around New York City.

JOHN C. BISSET, previously assistant to the director of projects and planning of the Texas WPA, is now regional engineer of the WPA for Arkansas and Louisiana.

E. H. BARKMANN has been promoted from the position of assistant chief engineer of the Missouri Valley Bridge and Iron Company at Leavenworth, Kans., to that of chief engineer.

JOHN F. BRUCE has resigned as topographic draftsman in the U. S. Engineer Office at Omaha, Nebr., to become connected with the Henningson Engineering Company, of the same city.

HENRY J. TEBOW has been transferred from the position of assistant engineer in the Hydrography and Investigations Section of the U. S. Bureau of Reclamation at Denver, Colo., to Boise, Idaho, where he will work on an investigation of the Boise Reclamation Project.

ARTHUR C. DENNIS is now general superintendent of the Dravo Corporation at Kerhonkson, N.Y.

VINCENT R. CARTELLI, formerly connected with the Emergency Relief Bureau, is now with Gibbs and Hill, consulting engineers of New York City.

F. T. MAVIS is now professor and head of the department of mechanics and hydraulics at the University of Iowa. He was formerly associate director of the Institute of Hydraulic Research at the university and acting head of the department.

E. A. ROLISON has resigned from his position as principal engineer for the Rural Electrification Administration in Washington, D.C., to become county manager of San Mateo County, California. His headquarters are at Redwood City, Calif.

JAMES R. RUMSEY, formerly superintendent of the Grand Rapids (Mich.) sewage treatment plant, has joined the staff of Greeley and Hansen, at Buffalo, N.Y., where he is constructing a sewage treatment plant.

KNOWLES K. MADISON, who for the past year has been highway engineer of Van Buren County, Michigan, is now with the Commonwealth and Southern Corporation, of Jackson, Mich.

HARRY E. MILLER has joined the teaching staff of the University of Michigan. Previously Mr. Miller was special supervising engineer in the rural sanitation division of the U. S. Public Health Service, in Washington, D.C.

ROBERT A. MONROE, previously senior engineer in the U. S. Bureau of Reclamation at Denver, has been appointed head water-control planning engineer with the Tennessee Valley Authority in Knoxville.

V. W. ANCKAITIS recently resigned as administrative assistant for the WPA in District 3, comprising four counties in Pennsylvania, to become an engineer for the Tilghman Moyer Company, architects, engineers, and contractors, of Allentown, Pa.

JOSEPH D. BLATT has resigned as estimator and designer for the Return Concrete Corporation to become assistant engineer for David M. Oltarsh, Inc., consulting engineers of New York City.

HAROLD N. DAVIDSON is now employed in the construction and equipment department of the Montgomery Ward Company in Chicago, Ill. He was formerly instrumentman and office engineer for the Arkansas State Highway Department.

ANDREW H. HOLT, professor of civil engineering at the State University of Iowa, has been appointed head of the civil engineering department at Worcester Polytechnic Institute. Professor Holt has been connected with the State University of Iowa since 1914.

ROBERT H. FORD has been appointed chief engineer of the Chicago, Rock Island and Pacific Railway Company, with headquarters in Chicago, Ill. He was formerly assistant chief engineer of this railroad.

ROBERT A. VOELKER, previously senior engineer for the Hamilton County (Tennessee) Regional Planning Commission, recently accepted a position as instructor in civil engineering at Antioch College, Yellow Springs, Ohio.

DECEASED

WILLIAM MAJOR BEAMAN (M. '28) chief of the section of inspection and editing of topographic maps for the U. S. Geological Survey, died recently in Washington, D.C., at the age of 69. Immediately after his graduation from the Massachusetts Institute of Technology in 1889, Mr. Beaman became connected with the Survey, rising from the rank of topographic aid to the position held at the time of his death, which he attained in 1922. During the war Mr. Beaman served in the Corps of Engineers, with the rank of major. He was the inventor of the Beaman arc, used in telescopic alidades, and the author of U. S. Geological Society publications on topographic mapping.

JOSEPH DUNTON BROWN (Assoc. M. '29) real estate engineer for the Connecticut Light and Power Company, died at his home at Southington, Conn., on March 8, 1937. Mr. Brown, who was 53, was born in Chelsea, Mass. From 1905 to 1913 he was rodman, inspector, and transitman for the New York, New Haven and Hartford Railroad Company, and from the latter year until 1918 was assistant engineer for the Connecticut Highway Department. He was then, successively, assistant engineer for the J. A. Crisfield Contracting Company, of Philadelphia, Pa., and resident engineer on mill construction for the Lockwood Greene Company, of Boston, Mass. In 1920 Mr. Brown became real estate engineer for the Connecticut Light and Power Company.

ERLE LONG COPE (M. '17) superintendent of the Bureau of Building Inspection, San Francisco, Calif., died on March 19, 1937. Mr. Cope, who was 54, was born in Meridian, Calif. Following his graduation from the University of California in 1906, he became a designing engineer for Cauchot and O'Shaughnessy. Later he was resident engineer on the construction of the Dalzura Conduit for the San Diego water supply, and from 1909 to 1911 he was superintendent of construction work at the University of California. In 1912 Mr. Cope established a consulting practice in San Francisco, which he maintained until 1934. In the latter year he was appointed chief of the Bureau of Building Inspection.

ARCHIBALD STEWART DOWNEY (M. '09) civil engineer and general contractor (with the A. W. Quist Company) of Seattle, Wash., died on February 26, 1937. Mr. Downey was born at St. Catharines, Ontario, on April 3, 1874, and graduated from Cornell University in 1896. After two years as engineer in the hydraulic laboratory at Cornell University, he served with the 1st U. S. Volunteer Engineers in the Spanish-American War. From 1903 until 1908 he had a general engineering practice in Seattle, and in the latter year he became a member of the firm, the A. W. Quist Company, doing general contract and construction work.

CONRAD FRANCIS DYKEMAN (Assoc. M. '13) consulting engineer of Brooklyn, N.Y., died on March 18, 1937. He was born in Brooklyn on May 8, 1885. In 1912 Mr. Dykeman became an engineer for the Underpinning and Foundation Company, Inc., of New York City, where he remained until 1936. During this period he designed the underpinning of over 500 buildings and was in charge of the construction of four sections of the New York subways and of many large-building foundations. In 1932 he was made chief engineer. During the war Mr. Dykeman was a first lieutenant with the 116th Engineers.

PAUL EVANS GREEN (M. '12) president of Marr, Green and Opper, consulting engineers of Chicago, Ill., died on March 12, 1937. He was 57. Mr. Green was born in Richmond, Ind., and graduated from the University of West Virginia in 1899. From that year until 1905 he was engaged in design and construction work for various railroads in the Middle West, and from 1906 to 1910 was engineer for the city of Chicago, in general charge of North Side improvements. From 1908 on, he was a member of the firm of Marr, Green and Opper, which performed engineering work for over one hundred cities and towns in the Middle West. During the war Mr. Green was district engineer for the U. S. Housing Bureau, and lately had held several advisory and consulting positions with the government.

FREDERICK JOSEPH GUBELMAN (Assoc. M. '95) president of the New Era Manufacturing Company, of Paterson, N.J., died on July 1, 1936. Mr. Gubelman was born in 1869 and graduated from Stevens Institute of Technology in 1889. His early career included experience as mechanical engineer for the East Jersey Pipe Works, of Paterson, N.J., and as chief assistant supervising engineer on the construction of water works for Allegheny, Pa. Later he was secretary and treasurer of the Gubelman Publishing Company; president of the Eastern Construction Company of New Jersey; and vice-president of the O'Rourke Engineering Construction Company, of New York City.

Mr. Gubelman served as president of the New Era Manufacturing Company for a number of years.

LEWIS MUHLENBERG HAUPT (M. '88) consulting engineer of Philadelphia, Pa., died at his home in Bala-Cynwyd, Pa., on March 10, 1937, at the age of 93. Professor Haupt was born at Gettysburg, Pa., and educated at Harvard University and West Point, graduating from the latter in 1867. During his early engineering career he was responsible for much of the layout of Fairmount Park, in Philadelphia, and from 1875 to 1892 he was professor of civil engineering at the University of Pennsylvania. In the latter year he resigned to establish the consulting practice that he maintained until his death. Professor Haupt was an authority on water and transportation problems and served on the Panama Canal Commission. He was the author of many papers on engineering subjects.

JOSEPH MILTON HOWE (M. '08) consulting engineer of Houston, Tex., died on March 22, 1937. Mr. Howe was born in Houston on July 30, 1874, and graduated from the Massachusetts Institute of Technology in 1896. His early engineering career included experience with the Gulf, Colorado and Santa Fe Railway; the Houston and Texas Central Railway; and the Southern Pacific Railway. In 1904 he became a member of the consulting firm, Howe and Wise, engaged in municipal, highway, and drainage practice. Mr. Howe was the author of many technical articles. From 1924 to 1926 he served as Director of the Society, and in 1930 and 1931 he was Vice-President.

DAVID RAMSAY (M. '23) of Nutley, N.J., died in Passaic, N.J., on February 1, 1937. Mr. Ramsay, who was 62, was born in Jersey City. Following his graduation from Rensselaer Polytechnic Institute in 1903, he became connected with the Roebling Construction Company in New York City, where he remained until 1913. From the latter year until 1920 he was engineer and superintendent on major building operations for Marc Eidlitz and Son, Inc., of New York City, and from 1921 until 1926 he was assistant engineer for the New York Central Railroad Company. After two years with the Long Island Railroad, Mr. Ramsay then became assistant town engineer for Nutley, remaining in this position until 1932.

The Society welcomes additional biographical material to supplement these brief notes and to be available for use in the official memoirs for "Transactions."

HORACE STRINGFELLOW (M. '21) executive representative of the Missouri Pacific Lines, was killed in an accident on January 1, 1937. Mr. Stringfellow was born in Montgomery, Ala., on March 28, 1882, and graduated from the University of the South in 1902. From 1903 to 1919 he held various positions with the Southern Railway, finally becoming district engineer. In 1924, after four years as regional engineer for the Southern and Pocahontas Regions of the United States Railroad Administration, he became special assistant to the president of the Missouri Pacific Railroad Company. In 1934 he was made executive representative.

EUGENE E. WISSOTSKY (Assoc. M. '24) designing engineer for Madigan-Hyland Engineers, of New York City, died in February 1937, at the age of 51. Mr. Wissotsky was born in Turkestan, Russia, and educated at Michael Artillery College and the Petrograd Academy. During the war he was research engineer for the Russian Scientific Artillery Committee; from 1917 to 1919 he was a member of the Special Russian Artillery Commission in the United States; and from 1919 to 1923 he was with the staff of the Russian Embassy in Washington, D.C. Later Mr. Wissotsky was structural designer for the New York Central Railroad, where he remained until 1932. In 1935 he became connected with Madigan-Hyland.

DAVID LEROY YARNELL (M. '20) senior drainage engineer in the Bureau of Agricultural Engineering of the U. S. Department of Agriculture, died suddenly at his home in Iowa City, Iowa, on March 9, 1937. Mr. Yarnell was born at Storm Lake, Iowa, on January 13, 1885, and graduated from Iowa State College in 1908. In 1909 he started work with the Department of Agriculture, for which he made special investigations and surveys of drainage and flood-control projects in various parts of the country. In 1922 the Department placed him in charge of hydraulic investigations at the hydraulic laboratory at the University of Iowa. He was among the first of American engineers to recognize the value of river model studies. Mr. Yarnell was the author of numerous papers and bulletins, and in 1933 he was joint recipient of the Society's James R. Croes Medal.

Changes in Membership Grades

Additions, Transfers, Reinstatements, and Resignations

From March 10 to April 9, 1937, Inclusive

ADDITIONS TO MEMBERSHIP

AHRENHOLZ, KENNETH RICHARD (Jun. '37), 467 Thirteenth St., Brooklyn, N.Y.

ARATA, WINFIELD HECTOR (Assoc. M. '36), Associate Concrete Insp., Golden Gate Bridge and Highway Dist. (Res., 1680 Sloat Boulevard), San Francisco, Calif.

BAMBERGER, SIDNEY FRANCIS (Jun. '36), 276 South El Molino, Pasadena, Calif.

BEAVERS, MERWIN GORDON (Jun. '36), 210 Santa Fe Bldg., Galveston, Tex.

BUEHLER, BOB JOHN (Jun. '37), Junior Hydr. Engr., TVA (Res., 218 East Baxter), Knoxville, Tenn.

CALDWELL, WILLIAM WEBSTER (Assoc. M. '37), Care, The J. G. White Eng. Corporation, 80 Broad St., New York, N.Y.

CHEN, CHAO WOO (Jun. '36), East Gate, Tsingkiang, Kiangsu, China.

COLTON, DUDLEY TEEPELL (Assoc. M. '37), Research Engr., Johns-Manville Research Laboratories, Manville, N.J.

COMELLA, WILLIAM OLIVER (Jun. '36), 4319 Garrison Boulevard, Baltimore, Md.

CORBETT, JAMES IRVING (M. '37), U. S. Engr. Office, Louisville, Ky.

CORNELL, RUSSEL MARBLE (Jun. '36), 2525 Colfax Ave., South, Minneapolis, Minn.

CRUDEN, RAYMOND NICHOLAS (Jun. '36), With U. S. Dept. of the Interior, Box 1481, Juneau, Alaska.

CULLUM, ROBERT SEVERNE (Jun. '37), Dist. Field Supervisor and Supervisor of Safety, WPA (Res., 1522 West Beauregard St.), San Angelo, Tex.

CUNDARI, JOSEPH ANTHONY (Jun. '36), 13 North 4th St., Harrison, N.J.

DOBBINS, WILLIAM EARL (Jun. '36), Instr., Civ. Eng., Robert Coll., Posta Kutusu 8, Bebek, Istanbul, Turkey.

ECKLUND, CONRAD ARTHUR (M. '37), Senior Topographic Engr., U. S. Geological Survey, Sacramento, Calif.

ELDER, JOHN WILLIAM (Jun. '36), Care, M. C. Foy & Son, Dighton, Kans.

ELL, HENRY THEODORE (Jun. '36), 252 Ellery Ave., Newark, N.J.

ENDERLIN, HAROLD CECIL (Jun. '37), Project Designing Engr., U. S. SCS, Box 116, Vacaville, Calif.

FERNANDEZ, MIGUEL ANGEL (Jun. '37), Instrumentman, WPA, City of New York (Res. 580 West 161st St.), New York, N.Y.

FETTERS, HOWARD FREDERICK (Jun. '36), 319 South 5th Ave., Ann Arbor, Mich.

Fischer, Philip Conrad (Jun. '37), Draftsman, Dept. of Water Supply, Gas and Electricity, New York City, Room 2342, Municipal Bldg., New York, N.Y.

Forrest, Kyle (Assoc. M. '36), Hydrological Investigator for Nassau County, U. S. Geological Survey, Mineola (Res., 160 Primrose Rd., Williston Park), N.Y.

Fowlkes, Benjamin Cobb, Jr. (Assoc. M. '37), Asst. to U. S. Dist. Engr., U. S. Engr. Office, Tygart Dam, Grafton, W.Va.

Gardner, Julius Braden (Jun. '37), Junior Hydr. Engr., TVA, Knoxville, Tenn.

Ginesin, Samuel (Jun. '36), 437 Amboy St., Brooklyn, N.Y.

Gott, Estep Tillard (M. '37), Vice-Pres., Dravo Corporation, Neville Island Station, Pittsburgh (Res., 1306 Beaver Rd., Sewickley), Pa.

Graff, Robert Lowell (Jun. '36), Commercial Hotel, Tipton, Ind.

Greene, William Jeff, Jr. (Jun. '36), Box 22, Fairburn, Ga.

Greenfield, Frank Lynne (Assoc. M. '37), Asst. Superv. Engr., WPA, 70 Columbus Ave., New York (Res., 144-31 Barclay Ave., Flushing), N.Y.

Greenleaf, John Whittier, Jr. (Jun. '36), Care, X. Henry Goodnough, Inc., 14 Beacon St., Room 404, Boston, Mass.

Harley, Roy Grant (Jun. '36), Engr., Am. Steel & Wire Co., Cleveland (Res., 2736 Lancashire Rd., Cleveland Heights), Ohio.

Harris, Walter Clarence (Jun. '37), Junior Bridge Const. Engr., State of California, 577 McKinley Ave., Fresno, Calif.

Haskins, Albert Raymond (Jun. '37), Draftsman, Universal Oil Products Co. (Res., 1537 West 104th St.), Chicago, Ill.

Herman, Donald Eugene (Jun. '36), 1650 Aberdeen St., Chicago Heights, Ill.

Holton, Hyrum Perry (Jun. '36), Topographic Draftsman, U. S. A. Engrs., 1319 Clay St., Vicksburg, Miss.

Ivy, Raymond Jennyings (Jun. '37), Junior Bridge Constr. Engr., Bridge Dept., State Div. of Highways, 2828 Grove St., Berkeley, Calif.

Jones, Paul Stevenson (Jun. '36), Junior Civ. Engr., Dept. of Water and Power, City of Los Angeles, Independence (Res., 5431 Aldoma St., Los Angeles), Calif.

Kinghorn, Anderson Mills (Jun. '36), Beaufort, S.C.

Kingsland, Lawrence Myrick (Assoc. M. '37), Topographic Engr., Brazos River Conservation and Reclamation Dist., Box 71, Mineral Wells, Tex.

Knudsen, Clarence Virgil (Jun. '37), Bridge Detailer, State Dept. of Roads and Irrig. (Res., 641 South 30th St.), Lincoln, Nebr.

Luippold, Jerome William (Jun. '37), Chainman, Eng. Dept., Bethlehem Steel Corporation, Lackawanna (Res., 33 Shirley Ave., Buffalo), N.Y.

McNown, John Stephenson (Jun. '36), 219 Riverview, Iowa City, Iowa.

Mann, Neil Warren (Jun. '36), 1311 Republic Bank Bldg., Dallas, Tex.

Martin, Hunt Vreeland (Assoc. M. '37), Lieut., C.E.C., U.S.N., Marine Barracks, Charlotte Amalie, Virgin Islands.

Martinez, Henry Augustus (Jun. '36), Rodman, Bureau of Reclamation, Box 1743, Casper, Wyo.

Mettler, Charles Leroy (Jun. '37), With Black & Veatch (Res., 4112 Locust, Apartment 5), Kansas City, Mo.

Mills, John Pardon, Jr. (Jun. '37), Chf. of Party, State Highway Loadometer Party, Lynnhaven, Va.

Olson, Carl Olaf (Jun. '36), 2 Webster St., Malden, Mass.

Orhon, Ekrem (Jun. '36), Rize, Turkey.

Parratt, Lyle Franklin (Jun. '37), With Gibbs & Hill, New York (Res., 47-17 Thirty-Ninth St., Long Island City), N.Y.

Partain, Alfred William (Assoc. M. '37), Field Engr. for County Engr., Nueces County, 1014 Furman Ave., Corpus Christi, Tex.

Peterson, Alton Haws (Jun. '36), Rodman, U. S. Bureau of Reclamation, Box 84, Mendon, Utah.

Raleigh, John Clark (Jun. '36), 859 North Hamlin Ave., Chicago, Ill.

Reid, John Henry (Jun. '37), Constr. Engr., Thomas F. Bowe, 110 William St. (Res., 1309 Herschell St.), New York, N.Y.

Riess, Frank (Jun. '37), 1420 Octavia St., New Orleans, La.

Roberts, Albert Kimball (Jun. '36), Care, Perry McGlone Const. Co., 600 City Bank Bldg., Kansas City, Mo.

Roose, Manley Allyn (Jun. '36), Under Eng. Aide, Eng. Service Div., TVA (Res., 14 North Seminole Drive), Chattanooga, Tenn.

Runstad, Harold John (Jun. '36), 3701 Thirty-Eighth South, Seattle, Wash.

Sawyer, Alfred Worcester (Jun. '37), Junior Asst. Engr., Malcolm Pirnie, 25 West 43d St., New York, N.Y.

Scranton, Clarence Henry (Jun. '37), 334 Glenwood Drive, Ambridge, Pa.

Shea, Herman James (Jun. '37), Instr., Mass. Inst. of Tech., Cambridge, Mass.

Sherman, Leslie Kimber (Assoc. M. '37), Senior San. Engr., State Dept. of Health, Hartford (Res., 839 Farmington Ave., West Hartford), Conn.

Shockley, Woodland Gray (Jun. '37), Draftsman, Buckeye Incubator Co., Springfield (Res., 119 Davis St., Yellow Springs), Ohio.

Smith, Charles Pixley (Assoc. M. '36), Res. Engr. Insp., U. S. Bureau of Public Roads, Box 565, Houston, Tex.

Steele, Francis Warren (Jun. '36), 2217 Second St., N.W., Washington, D.C.

Stone, Franklin Webb (Jun. '36), Care, Armstrong Cork Products Co., 232 West 7th St., Cincinnati, Ohio.

Wagener, August Hans (Assoc. M. '37), Asst. Engr., Eng. Dept., City of Rochester (Res., 579 University Ave.), Rochester, N.Y.

Walthall, Joseph Edward, Jr. (Jun. '36), 403 Linwood Ave., East Point, Ga.

TOTAL MEMBERSHIP AS OF APRIL 9, 1937

Members	5,656
Associate Members	6,088
Corporate Members	11,744
Honorary Members	24
Juniors	3,473
Affiliates	87
Fellows	1
Total	15,329

Warlam, Arpad Antal (Jun. '37), Kereskedelmi Minisztérium (Res., 7, Hieronymi ut), Budapest I, Hungary.

Wyller, Christian Frederik (Assoc. M. '36), Asst. Highway Engr., Bureau of Public Roads, Box 2311, Juneau, Alaska.

Yahyabek, Khairy Said (Jun. '36), Bab-Lekish 21/9, Mosul, Iraq.

Membership Transfers

Berndtson, Bernhardt Taylor (Jun. '34; Assoc. M. '37), Junior Highway Engr., State Div. of Highways, Dist. III, Box 911, Marysville (Res., 1450 Alice St., Oakland), Calif.

Bond, John Henry, Jr. (Jun. '26; Assoc. M. '37), Estimator and Designer, Bethlehem Steel Co. (Res., 443 Washington Ave.), Bethlehem, Pa.

Caldwell, William Metz (Jun. '27; Assoc. M. '36), Instr., Pratt Inst., Ryerson St. (Res., 161 Emerson Pl.), Brooklyn, N.Y.

Campbell, Frank Bixby (Jun. '28; Assoc. M. '37), Associate Soil Conservationist, SCS, 140 Connecticut Ave., Spartanburg, S.C.

Cosgrove, Frank Hester (Jun. '28; Assoc. M. '37), Junior Engr., U. S. Forest Service, 103 Fairhaven Rd., Worcester, Mass.

Drury, Walter Rhodes (Jun. '13; Assoc. M. '18; M. '37), Cons. Engr. (Shoecraft, Drury & McNamee), 103 East Washington St., Ann Arbor, Mich.

Evans, Thomas Hayhurst (Jun. '30; Assoc. M. '37), Asst. Prof., Civ. Eng., Dept. of Eng., Univ. of Virginia, Charlottesville, Va.

Gwin, Lewis Lyndsay (Jun. '28; Assoc. M. '37), Office Engr., Hunter & Caldwell (Res., 106 Aldrich Ave.), Altoona, Pa.

Jelley, Joseph Franklin, Jr. (Jun. '31; Assoc. M. '37), Lieut., C.E.C., U.S.N., Asst. Public Works Officer, Naval Operating Base, Norfolk, Va.

Jost, Charles Frederick (Jun. '29; Assoc. M. '37), Cons. Engr. (Nicholas S. Hill Associates), 112 East 19th St., New York, N.Y.

Kunesh, Joseph Francis (Assoc. M. '20; M. '37), Asst. Chf. Engr., Board of Water Supply, City of Honolulu (Res., 4934 Mana Pl.), Honolulu, Hawaii.

Laurent, Raymond Joseph (Jun. '29; Assoc. M. '37), Supervisor, State-Wide Highway Planning Surveys, State Highway Comm. (Res., 443 North 14th St.), Baton Rouge, La.

Sagehorn, Ernest Henry (Jun. '28; Assoc. M. '36), Asst. Engr., State Dept. of Public Works, 1495 West Harding Way, Stockton, Calif.

Tomlinson, Henry Hansell (Jun. '26; Assoc. M. '37), Structural Engr. and Contr. (Widdicombe Eng. Co.), 1700 Sansom St. (Res., 832 Wynnewood Rd.), Philadelphia, Pa.

Van Orman, Clare Ralston (Jun. '34; Assoc. M. '36), Asst. Engr. (Civ.) U. S. Engr. Office, Kansas City Dist., 232 Mfrs. Exchange Bldg. (Res., 707 North 18th St.), Kansas City, Mo.

Wagner, Richard Allen (Jun. '30; Assoc. M. '37), Engr. of Investigations, Bridge Dept., State Div. of Highways, 806 California State Bldg., Los Angeles (Res., 2242 Midvale Ave., West Los Angeles), Calif.

Reinstatements

Dirlam, Clyde Nixon, Assoc. M., reinstated Feb. 3, 1937.

Epps, Thad Chandler, Assoc. M., reinstated Mar. 15, 1937.

Foote, Francis Chandler, M., reinstated Mar. 29, 1937.

Gough, William Griswold, Assoc. M., reinstated Feb. 18, 1937.

HESLOP, DERWENT GORDON, M., reinstated Mar. 2, 1937.

HOLMES, THOMAS HUGHES, Assoc. M., reinstated Mar. 15, 1937.

HOMEYER, MAX PAUL VON, Assoc. M., reinstated Mar. 25, 1937.

HOUGH, ULYSSES B., M., reinstated Mar. 15, 1937.

MAINARDI, POMPEY, Jun., reinstated Mar. 19, 1937.

STOVER, HARVEY DALE, Assoc. M., reinstated Feb. 25, 1937.

STUBBS, FRANK LYCURGUS, Jun., reinstated Nov. 4, 1936.

TELLER, CARL FREEMAN, Assoc. M., reinstated Mar. 5, 1937.

WEDDINGTON, CHARLES FOREMAN, Jun., reinstated Mar. 3, 1937.

WICK, WILLIAM SAMUEL JOSEPH, M., reinstated Feb. 3, 1937.

RESIGNATIONS

GALINATO, JUAN GALINATO, Jun., resigned Mar. 24, 1937.

HILL, ALBERT EDWARD, JR., Jun., resigned Apr. 2, 1937.

SANTELMANN, ALFRED WILLIAM, Assoc. M., resigned Mar. 8, 1937.

WANDMACHER, FREDERICK CORNELIUS, JR., Jun., resigned Mar. 29, 1937.

Applications for Admission or Transfer

Condensed Records to Facilitate Comment of Members to Board of Direction

May 1, 1937 NUMBER 5

The Constitution provides that the Board of Direction shall elect or reject all applicants for admission or for transfer. In order to determine justly the eligibility of each candidate, the Board must depend largely upon the membership for information.

Every member is urged, therefore, to scan carefully the list of candidates published each month in CIVIL ENGINEERING *and to furnish the Board with data which may aid in determining the eligibility of any applicant.*

It is especially urged that a definite recommendation as to the proper grading be given in each case, inasmuch as the grading must be based upon the opinions of those who know the applicant personally as well as upon the nature and extent of his professional experience. Any facts derogatory to the personal character or professional reputation of an applicant should be promptly communicated to the Board.

Communications relating to applicants are considered strictly confidential.

The Board of Direction will not consider the applications herein contained from residents of North America until the expiration of 30 days, and from non-residents of North America until the expiration of 90 days from the date of this list.

MINIMUM REQUIREMENTS FOR ADMISSION

GRADE	GENERAL REQUIREMENT	AGE	LENGTH OF ACTIVE PRACTICE	RESPONSIBLE CHARGE OF WORK
Member	Qualified to design as well as to direct important work	35 years	12 years*	5 years of important work
Associate Member	Qualified to direct work	27 years	8 years*	1 year
Junior	Qualified for sub-professional work	20 years†	4 years*	
Affiliate	Qualified by scientific acquirements or practical experience to cooperate with engineers	35 years	12 years*	5 years of important work
Fellow	Contributor to the permanent funds of the Society			

* Graduation from an engineering school of recognized reputation is equivalent to 4 years of active practice.
† Membership ceases at age of 33 unless transferred to higher grade.

The fact that applicants refer to certain members does not necessarily mean that such members endorse.

ADMISSIONS

ADAMS, WILLIAM SOLOMON, Parsons, Kans. (Age 37.) Res. Engr., Kansas Highway Comm. Refers to H. Allen, H. D. Barnes, W. V. Buck, O. J. Eidmann, F. W. Epps, R. M. Willis, R. B. Wills.

ALT, GLENN LESLIE, Ann Arbor, Mich. (Age 42.) Asst. Prof. of Civ. Eng., Univ. of Michigan. Refers to J. H. Cissel, E. L. Eriksen, L. M. Gram, W. C. Hoad, H. E. Riggs, R. H. Sherlock, A. L. Trout, C. O. Wisler.

BALDWIN, CHARLES RICHARD, Luray, Va. (Age 28.) Chf. of Party (Surveyman), U. S. Engr. Office, Huntington, W.Va., and Baltimore, Md., also acting as Computer, Instrumentman and Inspector. Refers to W. M. Austin, H. K. Bishop, R. W. Crum, J. D. Davis, H. Haygard, A. H. Iseley.

BANKSON, WOODFORD, New Rochelle, N.Y. (Age 32.) Estimator, North Eastern Constr. Co., New York City. Refers to G. H. Davis, H. W. Ferris, F. J. Laverty, G. I. Rhodes, F. X. Scanlan, J. W. Van Denburg, W. von Phul.

BELL, JAMES DOUGLAS, Bonneville, Ore. (Age 37.) Inspector, Prin. and Draftsman, U. S. Engrs. Refers to A. Bauer, C. B. Hopkins, C. W. Kimbrough, S. E. Sporseen, B. E. Torpen.

BIRD, CHARLES FRANKLIN, Ann Arbor, Mich. (Age 24.) With Shoecraft, Drury & McNamee on drafting and design. Refers to W. C. Hoad, H. W. King, R. L. McNamee, L. C. Maugh, C. O. Wisler.

BLOHM, ARTHUR WILLIAM PAUL, Baltimore, Md. (Age 37.) Asst. San. Engr., Maryland State Dept. of Health. Refers to B. E. Beavin, C. B. Bryant, F. H. Dryden, L. H. Enslow, G. L. Hall, H. R. Hall, C. E. Keefer, G. J. Requardt, A. Wolman.

BORISS, MARION ELMO, Birmingham, Ala. (Age 32.) Acting San. Engr., San. Dept., Jefferson County, Ala. Refers to J. A. C. Callan, W. H. Caruthers, J. W. Cotlin, A. C. Decker, D. A. Helmich, H. H. Hendon, C. A. Wilmore.

BRADY, VIRGIL RUE, Harlingen, Tex. (Age 39.) Associate Engr., Lower Rio Grande Flood Control Project, International Boundary Comm., El Paso, and San Benito, Tex. Refers to T. C. Forrest, Jr., J. L. Lytel, E. N. Noyes, N. H. Sayford, A. Tamm, B. F. Williams.

BROMLEY, DANIEL DUANE, Pima, Ariz. (Age 34.) Jun. Engr. and Project Supt., Div. of Grazing, U. S. Dept. of Interior. Refers to R. G. Baker, C. E. Griggs, A. F. Harter, V. H. Housholder, E. V. Miller, J. R. Van Horn.

BRUNER, FRANCIS DANIEL PASTORIUS, Petersburg, Va. (Age 38.) Asst. Civ. Engr., Resettlement Administration; Senior Engr. Foreman, National Park Service, Richmond, Va. Refers to E. E. Barnard, A. P. Bursley, J. H. Denniston, L. M. Gray, R. L. Holmes, C. Jacoby, T. B. Kiener.

BUTLER, WELDON COLLINS, Houston, Tex. (Age 23.) Refers to L. E. Grinter, J. T. L. McNew, J. J. Richey, C. E. Sandstedt.

CALDWELL, EUROPE ALEXANDER, New Orleans, La. (Age 38.) Gen. Supt., Louisiana Materials Co. Refers to R. L. Barnes, E. L. Erickson, J. M. Fourmy, N. E. Lant, J. R. Wendt, Sr., W. C. Youngs.

CALLAHAN, FELIX WOOD, San Angelo, Tex. (Age 20.) Dist. Supervisor of Operations, WPA, Dist. No. 19. Refers to E. A. Baugh, J. C. Bisset, F. O. Fernald, J. B. Jones, W. L. Kelly.

CAMERON, HOWARD JAMES, Cave City, Ky. (Age 26.) Asst. Civ. Engr., U. S. Dept. of Interior, National Park Service, Eastern Div., Branch of Land and Use, Washington, D.C. Refers to F. F. Gillen, J. C. Penn, R. L. Stevens, T. H. Strate, O. G. Taylor, J. W. Woermann.

CARSON, ARTHUR BRINTON, Philadelphia, Pa. (Age 30.) Asst. Engr. and Res. Engr., Albright & Friel, Inc. Refers to H. M. Freeburn, F. S. Friel, J. G. Gruss, J. D. Justin, F. H. O'Rourke.

CLARK, JOHN JAMES, St. Louis, Mo. (Age 33.) Senior Civ. Engr., Water Div., St. Louis, Mo. Refers to R. G. Alexander, L. R. Bowen, S. W. Bowen, W. R. Crecelius, L. A. Hoynck, C. A. Koerner, A. R. Ross.

COPP, CHARLES MOSES, Holdrege, Nebr. (Age 43.) Mgr., J. A. Tertelings & Sons, Haas, Doughty & Jones, and Morrison Knudsen Co. Inc., Supervising a Joint Canal Construction Project. Refers to J. A. Bruce, E. F. Haas, E. E. Halmos, J. P. Hogan, G. E. Johnson, D. D. Price.

COSTELLO, EDWARD CHARLES, Willoughby, Sydney, Australia. (Age 31.) Asst. Engr., Dept. of Works & Local Govt. (On loan from Dept. of

Rys.) Refers to C. F. Blain, T. B. Nicol. (Applies in accordance with Sec. 1, Art. I, of the By-Laws.)

Cumbison, Gerald Lloyd, Topeka, Kans. (Age 26.) Jun. Draftsman, State Highway Comm. of Kans. Refers to L. E. Conrad, O. J. Eidmann.

Del Bourgo, Jacob Joseph, New York City. (Age 42.) Concrete Designer, Pheonix Eng. Corporation. Refers to H. G. Babcock, V. Christian, J. Feld, R. Smillie, E. Welle, L. S. Whippen.

De Wolfe, Alonzo Pearson, Toledo, Ohio. (Age 30.) Rodman, Toledo Dept. of Public Service, Div. of Water. Refers to C. R. Bird, G. Champe, C. M. Mower, Jr., C. L. Piper, G. N. Schoonmaker.

Di Genova, Egidio Ottavio, Brooklyn, N.Y. (Age 43.) Senior Draftsman, U. S. Coast & Geodetic Survey, New York City. Refers to A. D. Crosett, R. L. Pfau, H. B. Seaman, S. E. Stott, C. M. Thomas.

Ehlers, Joseph Henry, Washington, D.C. (Age 44.) Liaison Officer, PWA, being Tech. Asst. to Asst. Administrator. Refers to J. A. Anderson, W. N. Carey, F. M. Masters, R. Ridgway, O. J. Todd, A. S. Tuttle, J. A. L. Waddell.

Epperson, Ellsworth James, Los Angeles, Calif. (Age 36.) Senior Civ. Engr., County Surveyor Dept., Storm Drain Div., County of Los Angeles. Refers to O. F. Cooley, W. F. Foster, A. Jones, G. W. Jones, T. I. Phelps.

Estes, Claud Williamson, Arlington, Tex. (Age 40.) Asst. County Engr., Tarrant County, Fort Worth, Tex. Refers to F. D. Hughes, W. O. Jones, W. L. Kelly, D. L. Lewis, F. E. Lovett, M. C. Nichols.

Fei, Hua, Cambridge, Mass. (Age 24.) Graduate Student, Harvard Univ. Refers to A. Casagrande, A. Haertlein, L. C. Urquhart.

Fitch, Kenneth Stuart, Sacramento, Calif. (Age 26.) Jun. Topographic Engr. (being Chf. of Plane-Table Party), Conservation Branch, U. S. Geological Survey. Refers to L. L. Bryan, H. H. Hodgeson.

Flux, Paul Albert Edward, Manchester, Conn. (Age 44.) With Bridge Div., Connecticut State Highway Dept. Refers to R. E. Bakenhus, H. L. Hilton, C. R. Johnson, E. B. Keating, E. G. Larson, J. T. Mathews, R. V. Miller, W. A. Pollard, Jr.

Fortney, Camden Page, Jr., Charleston, W. Va. (Age 21.) Res. Engr., City Incinerator. Refers to R. R. Barton, R. P. Davis, W. S. Downs, C. P. Fortney, P. J. Walsh.

Fox, Louis Edgar, Pocatello, Idaho. (Age 29.) Project Engr., Idaho Bureau of Highways. Refers to T. C. Adams, R. B. Ketchum, F. L. McAtee, J. V. Otter.

Freudenthal, Alfred, Tel Aviv, Palestine. (Age 31.) Senior Structural Engr., The Tel Aviv Harbor & Communication Council. Refers to A. E. Barrekette, P. W. Etkes. (Applies in accordance with Sec. 1, Art. I of the By-Laws.)

Goff, Wayne Leroy, Bonneville, Ore. (Age 31.) Asst. Engr. (Sec. Head, under Office Engr.), U. S. Engr. Dept. Refers to A. Bauer, J. R. Griffith, C. W. Kimbrough, G. E. Linton, F. Merryfield, S. E. Sporseen, B. E. Torpen.

Goldstein, Nathan, Brooklyn, N.Y. (Age 24.) Refers to W. Allan, T. H. Prentice.

Gosselin, Urban Damas, Pittsfield, Mass. (Age 33.) Job Engr., F. H. McGraw & Co., New York City. Refers to S. Baker, E. J. Beugler, G. H. Buck, L. F. Quirk, C. F. Wertz.

Greenbaum, Ervin, Washington, D.C. (Age 24.) Jun. Engr., Suburban Resettlement Div., Resettlement Administration. Refers to J. L. Crane, Jr., L. M. Gram, W. E. Kroening.

Gregg, Duncan Smith, Bonneville, Ore. (Age 27.) Engr., W. A. Bechtel Co. and Columbia Constr. Co. Refers to C. Derleth, Jr., A. Donaldson, B. A. Etcheverry, R. H. Taylor, B. E. Torpen.

Hanson, Archie James, Tucson, Ariz. (Age 24.) Jun. Hydr. Engr., U. S. Geological Survey. Refers to J. A. Baumgartner, W. E. Dickinson, J. S. Gatewood, W. E. Smith.

Harris, Milton, Bishop, Calif. (Age 41.) Associate Highway Engr. California Div. of Highways. Refers to M. W. Ellis, C. Maughmer, J. H. Obermuller, A. L. Richardson, B. F. Rush, E. C. Thomas, R. H. Wilson.

Hass, Raymond Chester, Minneapolis, Minn. (Age 24.) Jun. Engr. (Hydr. and Structural), Minneapolis-St. Paul San. Dist., St. Paul, Minn. Refers to A. J. Duvall, G. J. Schroepfer, W. H. Sleeger, A. M. Steffes.

Hedrick, Terrence Otis, Topeka, Kans. (Age 36.) Asst. Bridge Designer, Kansas State Highway Comm. Refers to E. H. Connor, H. E. Durham, F. W. Epps, L. Grover, C. S. Heritage, C. S. Jones, A. N. Reece.

Hollister, Leonard Cochran, Sacramento, Calif. (Age 38.) Associate and Senior Bridge Engr. in charge of Drafting Room, Bridge Dept., State of California. Refers to C. E. Andrew, J. Gallagher, F. J. Grumm, J. M. Kane, F. W. Panhorst, C. S. Pope, R. H. Wilson.

Hotchkiss, William Otis, Troy, N.Y. (Age 58.) Pres., Rensselaer Polytechnic Inst. Refers to G. S. Davison, J. W. Doty, R. G. Finch, P. W. Henry, G. T. Horton, E. S. Jarrett, P. M. Sax.

Huttleston, Leonard Lamont, Johnson City, N.Y. (Age 32.) Project Mgr., Div. of Land Utilization, Binghamton, N.Y. Refers to F. A. Barnes, C. Crandall, F. P. Gilbert, G. L. Noble, H. B. Pope, C. W. Post, G. E. Rickard.

Ives, Howard Smith, Portland, Conn. (Age 36.) Asst. Project Engr. (on new Middletown, Portland Bridge construction), Connecticut Highway Dept.; also on private engineering. Refers to L. H. Beebe, A. W. Bushell, C. A. Campbell, A. M. McKenzie, S. B. Palmer.

Jackson, Robert James, Jr., Weehawken, N.J. (Age 22.) Refers to G. J. Davis, Jr., D.C.A. du Plantier, H. A. Kelly, J. S. Leister, F. J. Radigan.

Johnson, Irwin Twining, Sacramento, Calif. (Age 31.) Res. Engr., Bridge Dept., California Div. of Highways, on Castio cantilever bridge, Monterey County. Refers to C. E. Andrew, A. P. Denton, R. M. Gillis, H. M. Hadley, I. O. Jahlstrom, F. W. Panhorst, F. Pitzman, G. D. Whittle, R. H. Wilson.

Johnston, Roy Nelson, Topeka, Kans. (Age 35.) Dist. Supervisor and Asst. State Director, U. S. Public Health Service and State Board of Health. Refers to E. Boyce, C. C. Dills, R. E. Lawrence, W. C. McNown, F. A. Russell.

Johnston, Walter Wier, New York City. (Age 52.) Inspector Div., FEPWA. Refers to D. Bonner, G. W. Burpee, H. J. Deutschbein, J. W. Doty, M. E. Gilmore, H. M. Hale, R. H. Keays, J. A. Sargent.

Kemper, Paul Rodgers, Los Angeles, Calif. (Age 33.) Contr. Refers to A. Boyd, E. F. Chandler, M. Dozier, Jr., A. H. Koebig, Jr., E. F. Koenig, L. C. Larson, V. L. Peugh.

Kimball, Frank, Colorado Springs, Colo. (Age 40.) Associate Agri. Engr., Soil Conservation Service, Acting Chf. Engr. in State of Colorado. Refers to J. L. Burkholder, J. N. Gladding, J. C. Harvey, C. H. Howell, E. R. Kinnear, L. C. Rockett, R. H. A. Rupkey.

Kroll, Joseph, Bonneville, Ore. (Age 25.) Field Engr., Columbia Constr. Co. Refers to R. E. Davis, A. Donaldson, W. W. Laxton, R. H. Taylor, B. E. Torpen, G. E. Troxell.

Lendo, Alexander Chester, Orono, Maine. (Age 29.) Graduate Student and Asst., Dept. of Civ. Eng., Univ. of Maine. Refers to W. S. Evans, J. W. Howe.

Le Tellier, Louis Shepherd, Charleston, S.C. (Age 50.) Head of Dept. of Civ. Eng., The Citadel, The Military Coll. of South Carolina; also private practice. Refers to H. Beebe, E. L. Clarke, E. D. Clement, L. Y. Dawson, Jr., J. H. Dingle, J. E. Gibson, H. L. Hagerman, T. K. Legare, W. S. Lindsay, W. B. Rowe, J. E. Sirrine, R. L. Sumwalt.

Lovell, Leonard Arthur, North Platte, Nebr. (Age 29.) Office Engr., Platte Valley Public Power & Irrigation Dist., Sutherland Hydro-Elec. Project. Refers to K. F. Burnett, M. I. Evinger, E. E. Halmos, P. F. Keim, D. D. Price, F. M. Veatch, W. M. Wheeler.

McCain, Lester Albert, Ft. Smith, Ark. (Age 39.) Res. Engr. and Designer, Bridge Dept., Arkansas Highway Dept. Refers to F. P. Funda, J. H. Gardiner, N. B. Garver, R. C. Gibson, H. T. Livingston, W. R. Spencer, R. E. Warden, W. W. Zass.

McMahon, James Emmet, Long Beach, Calif. (Age 29.) Asst. Res. Engr., San Francisco-Oakland Bay Bridge. Refers to A. H. Brownfield, W. T. Haight, A. D. Hunting, I. L. Johnson, D. R. Warren.

Mains, William Whitridge, Topeka, Kans. (Age 32.) Sales Representative, American Rolling Mill Co., cooperating with State Highway Dept. on development of designs on flumes and pipe culverts. Refers to H. Allen, O. J. Eidmann, F. W. Epps, R. C. Keeling, L. F. Reynolds, M. A. Wilson.

Mallory, Edward Beach, Tenafly, N.J. (Age 53.) Cons. Engr., Lancaster Iron Works, Mfrs. of sewage-plant equipment. Refers to F. Bachmann, C. L. Bogert, J. H. Griffith, F. J. Gubelman, R. H. Jacobs, H. O. Pond, J. F. Sanborn, A. E. Stilson, R. E. J. Summers.

Marr, George Johnathon, Berkeley, Calif. (Age 30.) Chf. of Party on mountain road construction, U. S. Dept. of Agriculture. Refers to G. H. Fernald, R. S. Hawley, C. L. Young.

Maschmeyer, William Louis, Sardis, Miss. (Age 30.) Jun. Engr., U. S. Engrs., Vicksburg Dist., Sardis Damsite. Refers to R. C. Baker, T. A. Middlebrooks.

Meiklejohn, Robert, Jr., Grand Forks, N. Dak. (Age 22.) Asst. to Roadmaster and to Div. Roadmaster, Great Northern Ry. Co., M. of W. Dept. Refers to H. C. Bird, W. H. Hall, A. H. Metcalfe.

Moody, Ted Millard, McAllen, Tex. (Age 26.) Instrumentman and Jun. Asst. Engr., Constr. Div., International Boundary Comm. Flood Control. Refers to T. C. Forrest, Jr., W. W. Hall, C. T. Holmes, J. L. Lochridge, J. L. Lytel, E. N. Noyes.

Mosher, Arthur Augustin, Browning, Mont. (Age 27.) Road Engr., Blackfeet Indian Reservation. Refers to J. M. Brown, E. D. Duke, H. J. Doolittle, H. W. Gregory, C. A. McTaggart.

Ohlsen, Edward Henry, Ames, Iowa. (Age 36.) Instructor, Gen. Eng. Dept., Iowa State Coll. Refers to W. N. Adams, R. A. Caughey, A. H. Fuller, F. Kerekes, S. H. Smith, T. H. Strate.

Orrok, George Alexander, Jr., Cambridge, Mass. (Age 31.) Mech. Engr., Station Eng. Dept., The Edison Elec. Illuminating Co. of Boston. Refers to C. R. Bliss, E. A. Dow, G. M. Fair, G. Gilboy, L. J. Johnson.

Osmundson, Verne N., Blackduck, Minn. (Age 26.) Jun. Constr. Foreman, U. S. Forest Service, Chippewa National Forest. Refers to A. S. Cutler, L. G. Straub.

Phillips, Robert Marchant, Jr., Los Angeles, Calif. (Age 28.) Refers to R. M. Fox, D. M. Wilson.

Pitman, Edwin Price, Maplewood, N.J. (Age 38.) Asst. Engr. of Inspection, The Port of New York Authority, New York City. Refers to O. H. Ammann, M. B. Case, A. Dana, H. W. Hudson, G. L. Lucas, E. R. Needles, E. W. Stearns.

Pitts, Stanford McGraw, Cleburne, Tex. (Age 34.) Area Engr. (in charge of field work),

Brazos River Conservation & Reclamation Dist., Temple, Tex. Refers to E. A. Baugh, E. Haquinius, G. C. Morriss, J. A. Norris, O. S. Petty, W. C. Youngs.

RANSOM, JOHN GRAY, Rolla, Mo. (Age 32.) With U. S. Geological Survey, as Computer on office computation of transit traverse notes. Refers to E. J. Coon, H. H. Hodgeson, R. R. Monbeck, C. N. Mortenson, D. H. Rutledge, C. L. Sadler, R. G. Stevenson, W. B. Upton, Jr., R. M. Wilson, F. A. Wuopio.

RICKS, PAUL CARDON, Oakland, Calif. (Age 38.) Asst. to Engr. Appraiser, Federal Land Bank of Berkeley. Refers to A. S. Gelston, H. R. Howells, B. Jameyson, G. R. Loucks, G. H. Russell.

RIDENOUR, GERALD MARCELLUS, New Brunswick, N.J. (Age 35.) Research Engr., Dept. of Water & Sewage Research, Agricultural Experiment Station; Asst. Prof., Dept. of Water Supplies and Sewage Disposal, Rutgers Univ. Refers to A. R. Archer, H. G. Baity, L. L. Langford, H. N. Lendall, H. E. Miller, W. Rudolfs.

RODRIGUES DE BRITO, FRANCISCO SATURNINO, JR., Rio de Janeiro, Brazil. (Age 37.) Cons. Engr., F. Saturnino de Brito, Sr. Refers to E. B. Besselievre, R. F. Goudey, E. W. Lane, W. W. Morehouse, A. A. da Motta, J. T. de Oliveira Penteado, C. A. Wright.

ROSE, THOMAS DUNCAN, Durham, N.C. (Age 47.) State Engr. Inspector in North Carolina, PWA. Refers to T. C. Atwood, H. G. Baity, F. T. Miller, W. M. Piatt, D. M. Williams, S. H. Wright.

ROSEBERRY, GEORGE WILLIAM, Newton, Kans. (Age 45.) Senior Slab Inspector, Kansas Highway Comm. Refers to C. M. Barber, B. Boyle, P. L. Brockway, W. V. Buck, T. E. Burton, R. C. Ham, R. C. Keeling, W. S. McDaniel, J. A. Roby, B. C. Wells, R. B. Wills.

RUFAI, HASAN JAWAD, Najaf, Iraq. (Age 26.) Refers to W. J. Emmons, H. W. King, L. C. Maugh, R. H. Sherlock, C. O. Wisler.

SAFFAR AL HASSANI, HUSSEIN SEYID ALI, Baghdad, Iraq. (Age 23.) Refers to W. J. Emmons, H. W. King, L. C. Maugh, R. H. Sherlock, C. O. Wisler.

SHARISTANIAN, ARTHUR JACOB, Worcester, Mass. (Age 29.) Senior Civ. Engr., Massachusetts State Planning Board. Refers to A. W. French, R. F. Hall, J. W. Howe, A. J. Knight, C. F. Meyer, E. A. Taylor.

SMITH, EDWARD EPHRAIM, Lima, Ohio. (Age 45.) Gen. Supt., Dept. of Water & Sewage Treatment for City of Lima, Ohio. Refers to R. A. Allton, W. I. Barrows, J. W. Ellms, L. H. Enslow, D. R. Keith, A. E. Kimberly, H. W. Streeter.

SMITH, ROGER ADAMS, Pittsburgh, Pa. (Age 37.) Asst. Engr., War Dept., Corps of Engrs., being Group Leader, Design Div., Pittsburgh Dist. flood-control program. Refers to F. G. Christian, D. P. Grosshans, N. H. Jebejian, H. S. Kleinschmidt, H. C. Woods.

SMITHMEYER, PHILIP RAMBERG, Seattle, Wash. (Age 22.) Refers to G. E. Hawthorn, A. L. Miller, C. C. More, F. H. Rhodes, Jr., R. B. Van Horn.

STRAND, JOHN ANDREW, Madison, Wis. (Age 26.) With Mead, Ward & Hunt. Refers to F. M. Dawson, D. W. Mead, N. E. Minshall, F. E. Turneaure, C. N. Ward.

SWANSON, THEODORE ANDREW, Seattle, Wash. (Age 27.) Refers to G. E. Hawthorn, R. G. Hennes, A. L. Miller, C. C. More, R. G. Tyler, R. B. Van Horn.

THOMAS, ROY JAMES, Sheffield, Ala. (Age 29.) Prin. Eng. Aid, TVA, Wilson Dam, Ala. Refers to H. M. Clute, L. Evans, I. G. Hedrick, P. B. Hill, J. M. Wolfe.

THORSON, ROBERT DEAN, Los Angeles, Calif. (Age 30.) Associate Bridge Engr. (acting as Res. Engr.), Bridge Dept., Dept of Public Works, California Div. of Highways. Refers to C. E. Andrew, V. A. Endersby, J. Gallagher, W. M. Hall, F. W. Panhorst, D. R. Warren.

TODD, LAZARUS HOUSTON, Baton Rouge, La. (Age 27.) Eng. Aide, U. S. Engr. Corps, 2d New Orleans Dist., 2nd Area. Refers to G. N. Cox, G. J. Davis, Jr., D. C. A. du Plantier, S. C. Houser, B. W. Pegues.

TRACY, JOSEPH EDWARD, Albany, N.Y. (Age 37.) With The Pitometer Co., New York City. Refers to E. D. Case, E. S. Cole, R. H. Suttie, R. F. Wagner, E. K. Wilson.

TYLER, HUGH BISHOP, Concord, N.H. (Age 29.) Inspector, U. S. Engrs. Refers to R. S. Patton, F. L. Peacock, H. C. Stevens, W. W. Studdert, R. C. Vogt.

WALKER, DOUGLAS CRESSY, Indio, Calif. (Age 46.) Res. Engr. on Constr., Colorado River Aqueduct, Metropolitan Water Dist. of Southern California. Refers to G. E. Baker, E. A. Bayley, J. B. Bond, R. B. Diemer, F. W. Hough, J. Stearns.

WESTBROOK, JAMES AUGUSTUS, Chapel Hill, N.C. (Age 22.) Public Health Trainee, Univ. of North Carolina, North Carolina State Board of Health. Refers to H. G. Baity, G. M. Fair.

WOLF, ERNEST LAVERNE, San Francisco, Calif. (Age 60.) Chf. Eng. Draftsman, Public Works Dept., U. S. Navy. Refers to W. H. Allen, C. A. Carlson, E. C. Dohm, A. W. Earl, E. D. Graffin.

FOR TRANSFER

FROM THE GRADE OF ASSOCIATE MEMBER

ANGLE, JAMES MACFARLANE, Assoc. M., Montgomery, Ala. (Elected Jan. 17, 1921.) (Age 52.) Senior Highway Bridge Engr. (Dist. Bridge Engr.), Bureau of Public Roads. Refers to H. J. Friedman, O. L. Grover, H. H. Houk, N. E. Lant, H. J. Morrison, C. T. Nitteberg, W. I. Nolen, S. B. Slack.

CARLIN, PHILIP HENRY, Assoc. M., New York City. (Elected April 7, 1930.) (Age 36.) Editor of *Civil Engineering*, American Society of Civil Engineers. Refers to C. E. Beam, H. C. Berry, S. Harris, W. S. Pardoe, C. S. Shaughnessy, H. J. Sherman, C. H. Stevens.

GISIGER, PAUL EDWARD, Assoc. M., Baltimore, Md. (Elected Assoc. M. May 19, 1924.) (Age 41.) Structural Engr., Pennsylvania Water & Power Co., and Safe Harbor Water Power Corporation. Refers to F. A. Allmer, J. V. Hogan, W. W. Pagon, G. J. Requardt, J. A. Walls.

KINNISON, HARVEY BANKS, Assoc. M., Boston, Mass. (Elected Dec. 14, 1925.) (Age 46.) Dist. Engr., U. S. Geological Survey. Refers to N. C. Grover, R. S. Holmgren, J. C. Hoyt, K. R. Kennison, C. G. Paulsen, M. R. Stackpole, F. E. Winsor.

KOCH, VICTOR GEORGE, Assoc. M., Lufkin, Tex. (Elected Junior July 9, 1923; Assoc. M. April 12, 1926.) (Age 38.) Asst. Div. Engr., Texas Highway Dept. Refers to J. H. Brillhart, G. Gilchrist, D. C. Greer, T. E. Huffman, J. T. L. McNew, J. E. Pirie, C. L. Williford.

SCHROEDER, ROBERT ARMENAC, Assoc. M., Old Greenwich, Conn. (Elected Junior April 19, 1920; Assoc. M. May 28, 1923.) (Age 41.) Asst. to James D. Mooney, Vice-Pres., General Motors Corporation, New York City. Refers to R. B. H. Begg, H. L. Cooper, L. G. Puls, F. J. Sette, W. F. Way, I. A. Winter.

WALDO, WILLIS GERSHAM, Assoc. M., Washington, D.C. (Elected March 9, 1920.) (Age 53.) Cons. Engr. Refers to C. T. Bartlett, C. E. Edwards, Jr., A. C. Everham, B. P. Hessler, E. R. Hill, P. L. Holland, H. S. Hunt, A. B. McDaniel, R. B. McWhorter, C. A. Mees, L. D. Norsworthy, W. W. Pagon, G. B. Pillsbury, D. H. Sawyer, W. S. Winn.

FROM THE GRADE OF JUNIOR

BURKE, MAXWELL FOLLANSBEE, Jun., San Marino, Calif. (Elected April 15, 1929.) (Age 32.) With Los Angeles County Flood Control Dist., as Hydr. Engr. in charge. Refers to P. Baumann, S. M. Fisher, G. B. Gleason, N. B. Hodgkinson, C. H. Howell, F. B. Lavery, M. E. Salsbury.

FIELD, GILBERT ROBLIN, Jun., Richmond Heights, Mo. (Elected Nov. 12, 1928.) (Age 32.) With U. S. Engrs., Upper Mississippi Valley Div. Office. Refers to O. G. Baxter, F. G. Christian, C. H. Ellaby, A. F. Griffin, J. C. H. Lee.

GUYER, GEORGE ALLEN, Jun., Brookline, South Hills, Pittsburgh, Pa. (Elected Nov. 14, 1927.) (Age 32.) Associate Engr. (Asst. to Chf. of Instrumental Survey Sec.), U. S. Engr. Office, Pittsburgh, Pa. Refers to N. W. Bowden, H. C. Doverspike, H. A. Hickman, P. A. Fusin, E. P. Schuleen.

KAISER, EDGAR FOSBURGH, Jun., Bonneville, Ore. (Elected April 30, 1934.) (Age 28.) Mgr. of Operations, Columbia Constr. Co. Refers to K. L. Coltrin, F. T. Crowe, A. E. Horst, A. R. Olds, R. F. Walter.

MACDONALD, HOWARD DANIEL, Jun., Los Angeles, Calif. (Elected Oct. 14, 1929.) (Age 32.) Constr. Supt., Western Precipitation Corporation. Refers to H. G. Balcom, V. W. Bullock, L. T. Evans, C. C. More, L. K. Osborn, W. T. Wright.

OLIVER, JOHN CRAIG, Jun., Vancouver, B.C., Canada. (Elected June 10, 1929.) (Age 32.) Asst. Engr., Sewer and Water-Works Dept., City Engr.'s Office. Refers to E. E. Carpenter, E. A. Cleveland, W. E. Duckering, A. E. Finlay, J. R. Grant, G. M. Irwin.

POTTS, CHARLES EDWARD, JR., Jun., West Haven, Conn. (Elected Oct. 26, 1931.) (Age 27.) Engr. with Thomas F. Bowe, Cons. Engr. Refers to R. J. Behley, T. F. Bowe, W. J. Cox, P. G. Laurson, J. F. Lynch, C. J. Tilden.

ROBISON, FRANK WILBUR, Jun., Oceanside, Calif. (Elected Oct. 30, 1933.) (Age 33.) Jun. Bridge Constr. Engr., Bridge Dept., California Div. of Highways. Refers to C. E. Bissell, O. R. Bosso, C. Derleth, Jr., A. D. Hunting, I. L. Johnson, D. R. Warren, C. L. Young.

SHAH, DHIRAJLAL SOMCHAND, Jun., Mehsana, North Gujrat, India. (Elected Feb. 24, 1931.) (Age 33.) Asst. Engr., Gackwar's Baroda State Rys. Refers to J. B. Babcock, 3d, C. B. Breed, T. R. Camp, W. M. Fife, C. M. Spofford, C. H. Sutherland.

STANLEY, CLAUDE MAXWELL, Jun., Muscatine, Iowa. (Elected Nov. 15, 1926.) (Age 31.) Member of firm, Young & Stanley, Engrs. Refers to F. M. Dawson, W. W. DeBerard, J. S. Dodds, L. F. Harza, B. J. Lambert, S. M. Woodward, C. H. Young.

THOMPSON, JOHN CAVETT, Jun., Austin, Tex. (Elected May 29, 1933.) (Age 27.) Associate Engr. (Project Office Engr.), U. S. Bureau of Reclamation, on Colorado River Project in Texas. Refers to H. P. Bunger, J. H. Dorroh, C. H. Howell, M. J. Miller, C. P. Seger.

VANONI, VITO AUGUST, Jun., Pasadena, Calif. (Elected March 14, 1927.) (Age 32.) Project Mgr., Cooperative Research Laboratory of Soil Conservation Service and California Inst. of Technology. Refers to R. W. Binder, R. T. Knapp, R. R. Martel, F. Thomas, T. von Karman.

WIESNER, HENRY, JR., Jun., Millbury, Mass. (Elected Oct. 30, 1933.) (Age 32.) Asst. Div. Engr., Northeastern Water & Elec. Service Corporation. Refers to T. J. Blair, Jr., B. P. Boomsliter, L. V. Carpenter, R. P. Davis, W. S. Downs, W. J. Scott.

WILLIER, THOMAS EDWARD, Jun., Cambridge, Mass. (Elected Oct. 10, 1927.) (Age 32.) Fellow, Bureau for Street Traffic Research, Harvard Univ. Refers to H. Bartholomew, F. G. Jonah, J. H Long, E. M. Stayton, E. O. Sweetser.

The Board of Direction will consider the applications in this list not less than thirty days after the date of issue.